Lecture 1 – Introduction to Experimental Methods in Structural Engineering

Introduction of course contents and administrative issues:

1) Introduction of basic subjects
2) Introduction to topics
3) Introduction to resources available and required for the course
4) Introduction of class policies and requirements
5) Overview of experimentation issues
6) Grading
7) Visit of facilities virtual and physical
8) Safety instruction – lab visit component

Learning from Experience

CON-FU-CHI (known as CONFUCIUS in Latin)

"I read	→	*I see*
I listen	→	*I understand*
I do	→	*I know"*

It is only when you experience 'it' that you really know 'it'.

Modern Science and Engineering:

- Theory vs experimentation
- Analytical vs Physical Simulations
- Design vs Practice
- Knowledge-Skill-Methodology

Experimentation –

- quality of data
- reproducibility
- qualifications vs discovery
  - exploration
  - proof of concept
  - qualifications

Modern experimentation

- Combined analytical and physical simulations
- Destructive vs nondestructive testing
- Materials vs components vs structures
- Controlled loading vs random loading
- Electrical vs mechanical measurements

Course Goals

To introduce students to experimental methods, instrumentation, data acquisition, and data processing

The following subjects will be introduced:

1. Similitude, modeling and dimensional analysis (1wk)
2. Measurement systems, statistical and error analysis (1wk)
3. Test Planing, design and implementation - test protocols (2 wk)
4. Structural and Materials testing - steel, timber, plastics, concrete, etc.(1wk)
5. Loading Systems - set-ups, loading devices, actuators, control, etc. (2wk)
6. Instrumentation - mechanical, electrical, electronic (2wk)
7. Data Acquisition - analog and digital (1wk)
8. Computerized data processing - numerical and graphical (1wk)
9. Data archiving and curating- data quality control (1 wk)

Topics covered (not necessarily in this order):

Topic 01. Physical and numerical modeling; Introduction

Topic 02. Dimensional analysis and similitude; Accuracy and suitability of models

Topic 03. Design of an experimental study; Modeling, testing modeling…

Topic 04. Data acquisition; Measurement systems/transformations

Topic 05. Data analysis; signal processing, error analysis, statistical treatment of error

Topic 06. Materials testing; Introduction, instrumentation, setup

Topic 07. Structure testing; measurement set-ups

Topic 08. Load simulation; Experiment command and control, actuators and control systems, servohydraulic systems, control…

Topic 09. Loading simulation; Shake table testing, motion simulation

Topic 10. Load simulation; Quasi-static, dynamic, Pseudodynamic…

Topic 11. Loading simulation; Pseudodynamic, testing, numerical investigation,implicit/explicit investigation

Topic 12. Loading simulation; Hybrid dynamic substructuring

Topic 13. Instrumentation 1; Stress, force measurements

Topic 14. Instrumentation 2; Motion measurements and HEMS

Topic 15. Instrumentation 3; Pressure and temperature measurements

Topic 16. Instrumentation 4; Analogue and conditioning

Topic 17. Digital data processing, curvation and repository

Topic 18. Non-destructive testing for condition assessment; Dynamic, techniques, instrumentation (acoustic etc…)

Topic 19. Non-destructive tests; Proof load, qualification testing

Topic 20. Destructive testing; Prediction of failure mode

Topic 21. Monitoring structures; Continuous measurements, data transponders and wireless instruments

Topic 22. Data visualization; Standards and adv.

Resource Materials

1 Dally and Riley, "Experimental Stress Analysis,", McGraw Hill, 1978

2 Harris and Sabnis, "Structural Modeling and Experimental Techniques" CRC Press 1999

3 Nachtigal, C.L., "Instrumentation and Control," Wiley & Sons, 1990

4 Reese and Kawahara, " Handbook of Structural Testing", Prentice Hall / Fairmont Press 1993

5 Chopra, A, " Dynamics of Structures", Prentice Hall, 2nd Edition, 2001

6 Malhotra and Carino, "Handbook of Nondestructive Testing of Concrete", CRC Press, 1991

7 Data visualization toolbox from Matlab Link to author of "Visualizing Data", the source for Matlab's toolbox.

8 Instructor's Handouts / Computer Manuals

9 Equipment types and Instrumentation SEESL Lab Manual

10 Good strain gage data source from Micro Measurements Group

11 Guide to strain gage installation is also at Micro Measurements Group.

12 Fiber-optic strain gages is at AS-Overlay web site.

13 Data acquisition and analysis on National Instruments website (go to Resource Library).

14 A very well described and presented P-delta test from Buffalo.

15 SAC Steel Project Test Protocol Document.

16 MTS Corporation shaking table page. Watch the movies!

17 Etc. …….

Assignments

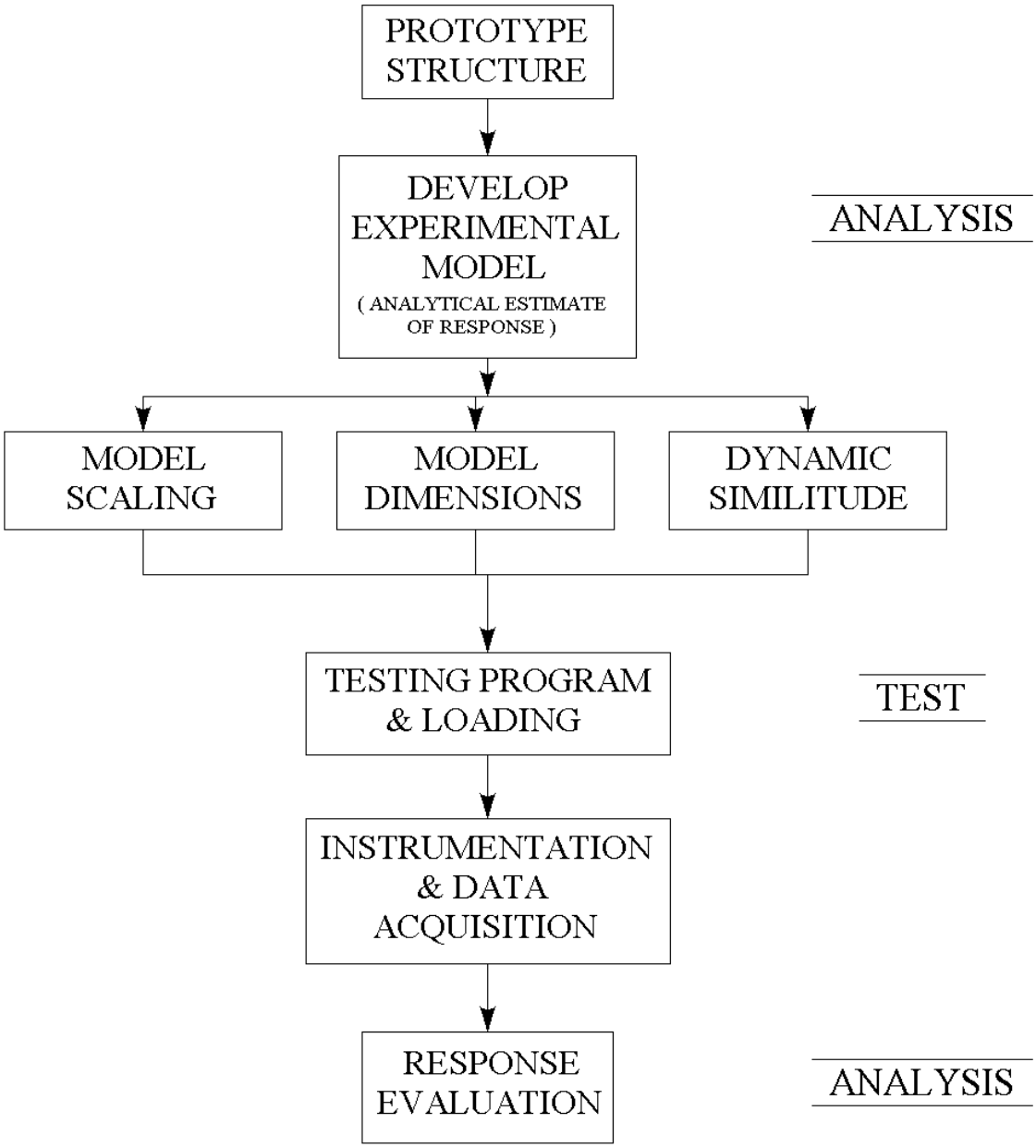
- Prerequisites: CIE519 completed or consent of Instructor.
- Meetings: Lectures and demonstartions Wednesdays two consecutive sessions of 80 minutes each.
- Labs: 3 hours weel;y. Schedule to be set weekly. Subjects and materials to be followed in class will be posted on the website. Please read ahead of class and be prepared to participate in discussions and hands on sessions.
- Homeworks will be lab reports as parts of a comprehensive project, taylored according to your interests. If you do not have a preference, the instructor will assign to you a project. Homeworks and project will be done in groups of two to three students.
- The report of the final project will be due on December 15 at 12:00 pm.

Grading

Home works (biweekly)*	Part of a case study project and individual assignments	(60% of final grade)
Mid-semester exam	All material to exam date	(0% of final grade)
Final examination	Project defense	(20% of final grade)
Final Project*	Case study	(20% of final grade)

*All homework and project will be done in groups of two to three students each.

Experimental Methods



LAB REPORT ORGANIZATION

1. Summary (executive summary)
   + Information about authors, sponsor, and other participants

2. Scope and general presentation
   2.1. Purpose and objectives of testing - general
   2.2. Prototype description
   2.3. Scope of testing
   2.4. Prototype design information – size etc where applicable
   2.5. Scaling and model development – similitude information
   2.6. Materials and constraints

3. Test-set-up overview
   3.1. Specimen / model description – including materials and component properties
   3.2. Loading system – description
   3.3. Instrumentation set-up and measurement system + calibration procedures
   3.4. Data acquisition + schematic information data flow
   3.5. Data archiving – structure, model, metadata, curation, transfer

4. Test procedures
   4.1. Test schedule & repetitions
   4.2. Data monitoring & checking during testing
   4.3. Test implementation – notes & metadata

5. Test Results – raw data
   5.1. Data recording and repository inventory
   5.2. Data verification & repository transfer
   5.3. Initial test results

6. Data processing
   6.1. Data checking, verification & recovery
   6.2. Determination of errors & elimination of errors
   6.3. Identifications of structural parameters and important properties
   6.4. Correction of test results through data processing – procedures

7. Analytical predictions (before modifying analytical models)
   7.1. Calculated model parameters using principles of engineering
   7.2. Calculated response using simplified or sophisticated model
   7.3. Calculated response using identified parameters

7.4. Comparison of response of experiment analysis with estimated and with measured parameters

8. Discussions and recommendations
   8.1. Discussion of information as obtained from tests
   8.2. Recommendation to reduce gap between computed and tested

The headings and subheadings may be further subdivided as needed by specific projects

Laws in Experimental Studies

1. Murphy's Law –If something can go wrong it will
2. O'Toole's Law –Murphy's Law is too optimistic
3. Reinhorn's Law –Things are never as bad as they turn out to be
4. Bracci's Law –Anything can be accomplished with time and ….. money

ACCESS TO SEESL LABORATORY

1. Laboratory operation hours are 8:30am to 4:30 pm, when the University is officially open. Anyone can be in the laboratory during operation hours provided that safety rules are followed.
2. Access to the laboratory at times other than normal operation hours of 8:30am to 4:30pm is restricted as follows:
    a. Only authorized personnel can enter.
    b. Authorization can be provided only by the permanent staff of the laboratory and approved by either Dr. Reinhorn or Dr. Constantinou.
    c. Students may work in the laboratory provided
        i. they receive authorization,
        ii. work in pairs, and
        iii. are previously instructed on what exact machinery they may use.
    d. Outside contractors may work in the laboratory provided
        i. they receive authorization
        ii. work in pairs, (or at least one other person is present in lab during work time) and
        iii. have a valid certificate of insurance, or a clearly signed waiver of claims to the laboratory, laboratory staff and University. (Waiver can be obtained at Lab Management office).
3. Outside contractors may use equipment in the laboratory provided they are properly trained, are authorized by the permanent staff of the laboratory, and have a valid certificate of insurance, or waiver as indicated in 2d (iii) above.
4. The permanent staff of the laboratory and either of the co-directors may order any person to leave the laboratory if they determine that person poses a safety threat to him/her self or others.

Prof. M. C. Constantinou
Department Chair CSEE

Prof A. M. Reinhorn
Director SEESL

SAFETY RULES AT SEESL LABORATORY

Failure to follow safety roles is grounds for suspension of laboratory privileges and/or removal from the laboratories

1. All personnel working in the laboratory, including students, shall wear safety shoes.
2. All personnel working in the laboratory, including students, and visitors shall wear safety hats, helmets, except in areas marked otherwise.
3. Any time welding is being done, the operation shall be shielded so that it is not possible for visitors to view the welding. Any volatile materials shall be removed to a safe distance before welding is performed.
4. Grinding is covered by of the same rules of welding. In addition, a non-flammable shelter should be built around the grinding operation to contain sparks.
5. Safety belts shall be used when climbing. Climbing is defined as any activity, which results in the person being more than four feet above the floor. Safety belts on ladders are optional.
6. The overhead cranes are to be used for lifting and moving. They are not to be used for pulling or breaking. Only authorized personal can use crane.
7. Operation of overhead cranes, testing machines, machine tools or power equipment shall take place ONLY when member of the full-time staff, or authorized designated person is present in laboratory.
8. All personnel shall wear long pants and socks when using power tools or machine tools.
9. Personnel shall wear gloves if there is any possibility of abrasion or laceration. When in doubt, gloves shall be worn.
10. Personnel shall wear safety glasses when operating a machine tool or power equipment.

IN CASE OF EMERGENCY CALL 9-2222 AND NOTIFY MEMBER OF THE PERMANENT STAFF IN LABORATORY

Prof. M. C. Constantinou
Department Chair CSEE

Prof A. M. Reinhorn
Director SEESL