Structural-Vibration Analysis, Design and Troubleshooting

Purpose and Background

The course may be divided into six parts:

1. Structural vibration fundamentals,
2. Analysis techniques,
3. Synthesis of analysis and test results,
4. Designing for dynamic forces,
5. Applications in residential and commercial buildings and industrial facilities, and
6. Example case histories.

Emphasis of the course is not on derivation of equations but on assumptions and limitations of various analysis technique, and guidelines on when to use which method. Twenty worked out numerical examples and five case studies are presented as necessary. The detailed step-by-step analysis/design example problems will serve as a useful guide for your projects. Participants will receive a comprehensive set of notes and a textbook as reference materials.

This is an intermediate level course. Learn how to compute the natural frequencies, mode shapes and forced-vibration response of structures and structural components. Benchmarking analytical results with test results or field data is also taught. A variety of methods for reducing excessive vibrations in new as well as existing structures are discussed (frequency separation techniques, variety of dampers, vibration absorbers (tuned-mass dampers), vibration isolators). Rotating equipment and foundations, earthquake analysis, blast loads, vibration isolation, structure-fluid systems and flow-induced vibrations are also discussed.

Emphasis of the course is not on derivation of equations but on assumptions and limitations of various analysis technique, and guidelines on when to use which method. Twenty (20) worked out example problems and five (5) case studies are presented to illustrate analysis and design. The detailed step-by-step analysis/design example problems will serve as a useful guide for your projects. Participants will receive a comprehensive set of notes and a textbook as reference materials. There will also be ample opportunity to interact with the instructor and discuss their questions.

Seminar Instructor

C. Raj Sundararajan, Ph.D., M.ASCE, has over 37 years of experience in the analysis and design of structures subjected to dynamic forces. He is President of EDA Consultants (formerly known as Engineering Dynamic Associates). Previously he held senior technical positions at Lummus Company, Foster Wheeler Corporation and Impell Corporation. He has published two books, over 50 technical papers, and authored numerous technical reports. He received the ASME Best Paper Award in 1986 and has taught short courses for practicing engineers for over 20 years. He has a B.E. in Civil Engineering from the University of Madras, India, an M.E. in Civil Engineering from the Indian Institute of Science, and a Ph.D. in Civil Engineering from the University of Waterloo, Canada.

- **To register your group, call John Wyrick (JWyrick@asce.org) or Stephanie Tomlinson (STomlinson@asce.org)**

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Summary Outline

DAY ONE

Structural Vibration Fundamentals

- Free vibration and forced vibration
- Analysis models for structural dynamic systems
- Types of damping
- Types of dynamic forces
- Representation of dynamic forces in the time and frequency domains

Analysis Techniques

- One-degree-of-freedom systems - Natural frequency and critical damping - Harmonic forces and the concept of resonance - Transient forces - Dynamic amplification factor - Forces transmitted to foundations - Base excitation- Response spectra
- Multiple-degrees-of-freedom systems - Natural frequencies and mode shapes - Direct time-history analysis - Modal time-history analysis - Response spectrum analysis

DAY TWO

- **Practical aspects of finite element modeling and analysis of vibration problems**
  This is not a course on finite element analysis. Course concentrates on the special aspects of modeling and analyzing complex structures for vibration analysis. Advantages and disadvantages of different methods of analysis such as coupled and decoupled analysis, and time-domain analysis and frequency-domain analysis are discussed with guidelines on which methods are best suited for what types of problems. Guidelines for mesh size, cut-off frequency and time-steps are also presented.
- **Modal Testing** - Test procedure - Interpretation of test data - Determination of natural frequencies, mode shapes and damping
- **Synthesis of Analysis and Test Results** - Test-analysis correlation - Fine-tuning finite element models using test data
- **Structural response to earthquakes**
- **Representation of base excitation**- Time-history analysis- Response spectrum analysis
- **Structural response to blast loads**- Blast load computation- Dynamic response analysis
- **Floor vibration due to machinery and human activities**
- **Rotating machinery vibrations**
- **Soil stiffness**, soil damping and foundation design for rotating machines

DAY THREE

- **Vibration Absorbers** (tuned-mass dampers) - Basic concepts, types of absorbers and design procedure
- **Vibration Isolators** - Basic concepts, types of isolators and design procedure
- **Designing for Dynamic Forces** - Design aspects are discussed throughout the course. Here the different strategies of reducing vibration are summarized and relative merits discussed with practical examples
- **Special Topics** - Basic concepts and overview of the following special topics are presented: - Fluid-structure systems - Flow-induced vibrations
- **Numerical Examples**: Twenty detailed, step-by-step worked out examples of analysis and design are presented at appropriate places throughout the course
- **Case Studies**: Five case histories are presented to demonstrate how the various concepts and methods presented in the course are applied in complex vibration projects. These projects are solved as group exercise to get participants working on complex projects with guidance from instructor

Seminar Benefits

- Compute natural frequencies of simple and complex structures
- Compute structural response to dynamic loads
- Compute structural response to base excitations (for example earthquakes)
- Design vibration absorbers (tuned-mass dampers)
- Design vibration isolators
- Design foundations for rotating equipment
- Troubleshoot and modify existing structures to reduce unacceptable levels of vibration

Who Should Attend?

Engineers and engineering supervisors who are responsible for designing or qualifying structures and structural components subjected to dynamic forces and those responsible for auditing, reviewing, or approving vibration analysis tasks will benefit from the course.

Those with very little experience in vibration analysis, as well as those with some years of experience, will find the course useful.

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