Substructures and Submodeling with Abaqus

About this Course

Course objectives
Upon completion of this course you will be able to:
- Understand the difference between substructuring and submodeling
- Build, translate, rotate and reflect substructures
- Build preloads into substructures
- Design meshes for submodel analysis
- Perform solid-to-solid, shell-to-shell, and shell-to-solid submodeling

Targeted audience
This course is recommended for engineers with experience using Abaqus/Standard.

Prerequisites
None
Day 1

- Lecture 1: Introduction to Substructures
- Lecture 2: Using Static Substructuring in Abaqus
- Lecture 3: Substructuring as a Linear Perturbation about a Preloaded State
- Lecture 4: Dynamic Substructuring
- Lecture 5: Substructure Output
- Lecture 6: Substructuring Examples
- Workshop 1a: Substructures: Plane Frame Analysis
- Workshop 1b: Substructures: Surface Mount Analysis
- Lecture 7: Using substructures with Abaqus/Explicit
- Workshop 2: Substructures: Beam Impact (optional)

Day 2

- Lecture 8: Introduction to Submodeling
- Lecture 9: Submodeling in Abaqus
- Lecture 10: Abaqus Usage and Examples (Part 1)
- Workshop 3: Submodeling: Pressure Vessel Nozzle Analysis
- Lecture 11: Abaqus Usage and Examples (Part 2)
- Workshop 4: Submodeling: Ceramic-Metal Braze Joint
- Lecture 12: Submodeling Practices
- Lecture 13: Limitations of Submodeling
Appendix 1: Theory of Substructures
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Lesson 1: Introduction to Substructures

The following topics are covered in this lesson.

Lesson content:
- Introduction to Substructures

Here are the steps to be followed:

1. Why Substructuring?
2. Static Substructuring
3. Advantages of Substructuring
4. Procedures Supporting Substructures
Lesson 2: Using Static Substructuring in Abaqus

The following topics are covered in this lesson.

Lesson content:
- Using Static Substructuring in Abaqus

Here are the steps to be followed:

1. The Basics
2. Substructure Generation
3. Substructure Usage: Abaqus/CAE
4. Substructure Usage: Keywords
5. Substructure Load Cases
6. Substructure Gravity Loading
7. Kinematic Constraints in Substructures
8. Limitations
Lesson 3: Substructuring as a Linear Perturbation about a Preloaded State

The following topics are covered in this lesson.

Lesson content:
- Substructuring as a Linear Perturbation about a Preloaded State

Here are the steps to be followed:
1. Introduction
2. Substructure Tangent Stiffness Calculation
3. Response Quantities
4. Effect of Preloads at the Usage Level
5. Preloading Syntax
6. Preloading Example: Rotating Structure
Lesson 4: Dynamic Substructuring

The following topics are covered in this lesson.

Lesson content:
- Dynamic Substructuring

Here are the steps to be followed:
1. Guyan Reduction
2. Dynamic Mode Addition
3. Damping with Substructures
Lesson 5: Substructure Output

The following topics are covered in this lesson.

Lesson content:
- Substructure Output

Here are the steps to be followed:

1. Introduction
2. Visualizing Substructure Results
3. Output of Eliminated Degrees of Freedom
4. Output of Substructure Matrices
5. Substructure Library Utilities
Lesson 6: Substructuring Examples

The following topics are covered in this lesson.

Lesson content:
- Substructuring Examples
- Workshop Preliminaries
- Workshop 1a: Substructures: Plane Frame Analysis (IA)
- Workshop 1a: Substructures: Plane Frame Analysis (KW)
- Workshop 1b: Substructures: Surface Mount Analysis (IA)
- Workshop 1b: Substructures: Surface Mount Analysis (KW)

Both interactive (IA) and keywords (KW) versions of the workshops are provided. Complete only one for each workshop.

3 hours

Here are the steps to be followed:

1. Cyclic Symmetry
2. Multilevel Substructuring
Lesson 7: Using Substructures with Abaqus/Explicit

The following topics are covered in this lesson.

Lesson content:
- Using Substructures with Abaqus/Explicit
- Workshop 2: Substructures: Beam Impact (IA)
- Workshop 2: Substructures: Beam Impact (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.

2 hours

Here are the steps to be followed:

1. Introduction
2. Examples
3. General Concepts
4. Keyword Interface
5. Interactive Interface
6. Postprocessing
7. Technology Notes
Lesson 8: Introduction to Submodeling

The following topics are covered in this lesson.

Lesson content:
- Introduction to Submodeling

Here are the steps to be followed:
1. Concept of Submodeling
2. Motivation for Submodeling
Lesson 9: Submodeling in Abaqus

The following topics are covered in this lesson.

Lesson content:
- Submodeling in Abaqus

Here are the steps to be followed:
1. Fundamental Assumptions
2. Submodeling Techniques
3. Node-based Implementation
4. Surface-based Implementation
Lesson 10: Abaqus Usage and Examples (Part 1)

The following topics are covered in this lesson.

Lesson content:
- Abaqus Usage and Examples (Part 1)
- Workshop 3: Submodeling: Pressure Vessel Nozzle Analysis (IA)
- Workshop 3: Submodeling: Pressure Vessel Nozzle Analysis (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.

2 ½ hours

Here are the steps to be followed:

1. Terminology
2. Transfer of Data
3. Prescribed Values
4. Submodeling Workflow
5. Surface-Based Submodel Boundaries
6. Example: Conical Crack in a Half Space
7. Example: Pressure Vessel
Lesson 11: Abaqus Usage and Examples (Part 2)

The following topics are covered in this lesson.

Lesson content:
- Abaqus Usage and Examples (Part 2)
- Workshop 4: Submodeling: Ceramic-Metal Braze Joint (IA)
- Workshop 4: Submodeling: Ceramic-Metal Braze Joint (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.

2 hours

Here are the steps to be followed:

1. Node-Based Submodel Boundaries
2. Example: Stacked Sheet Metal Assembly
3. Example: Large Displacement Analysis
4. Tolerances at the Submodel Boundary
5. Shell-to-Solid Submodeling
6. Example: Shell-to-Solid Submodel of a Pipe Joint
Lesson 12: Submodeling Practices

The following topics are covered in this lesson.

Lesson content:
- Submodeling Practices

Here are the steps to be followed:

1. Perturbation Analysis
2. Changing Procedures
3. The Frequency Domain
4. Submodeling and Thermal Stress Analysis
5. Example: Thermal Strain in a Bar
6. Submodeling in Dynamic Procedures
7. Example: Speaker Diaphragm (1/7)
Lesson 13: Limitations of Submodeling

The following topics are covered in this lesson.

Lesson content:
- Limitations of Submodeling

Here are the steps to be followed:

1. Elements
2. Procedures
3. Shell-to-Solid
Appendix 1: Theory of Substructures

The following topics are covered in this lesson.

Lesson content:
- Theory of Substructures

Here are the steps to be followed:
1. Static Substructuring
2. Guyan Reduction
3. Restrained Mode Addition