Analysis of Geotechnical Problems with Abaqus

2017
Course objectives
Upon completion of this course you will be able to:

- An overview of modeling geotechnical problems
- Experimental testing and how it relates to the calibration of constitutive models for geotechnical materials
- How to use and calibrate the different geotechnical material constitutive models available in Abaqus
- The limitations of these models
- The coupling between fluid flow and stress/deformation in the analysis of porous media
- Modeling issues related to geotechnical problems

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

Prerequisites
None
Day 1

- Lecture 1: Introduction
- Lecture 2: Physical Testing
- Lecture 3: Constitutive Models: Part 1
- Lecture 4: Constitutive Models: Part 2
- Workshop 1: Material Models for Geotechnical Applications
Day 2

- Lecture 5  Analysis of Porous Media
- Workshop 2  Pore Fluid Flow Analysis: Consolidation
- Lecture 6  Modeling Aspects
- Workshop 3  Pore Fluid Flow Analysis: Wicking
- Workshop 4  Mixing of Granular Media in a Drum Mixer (Optional)
<table>
<thead>
<tr>
<th>Appendix</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix 1</td>
<td>Stress Equilibrium and Fluid Continuity Equations</td>
</tr>
<tr>
<td>Appendix 2</td>
<td>Bibliography of Geotechnical Example Problems</td>
</tr>
<tr>
<td>Appendix 3</td>
<td>Infinite Domains</td>
</tr>
<tr>
<td>Appendix 4</td>
<td>Hydraulic Fracture</td>
</tr>
</tbody>
</table>
SIMULIA is the Dassault Systèmes brand for Realistic Simulation solutions

Portfolio of established, best-in-class products
- Abaqus, Isight, Tosca, fe-safe, Simpack

* Included in extended licensing pool
<table>
<thead>
<tr>
<th>SIMULIA’s Power of the Portfolio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abaqus</strong></td>
</tr>
<tr>
<td>• Routine and Advanced Simulation</td>
</tr>
<tr>
<td>• Linear and Nonlinear, Static and Dynamic</td>
</tr>
<tr>
<td>• Thermal, Electrical, Acoustics</td>
</tr>
<tr>
<td>• Extended Physics through Co-simulation</td>
</tr>
<tr>
<td>• Model Preparation and Visualization</td>
</tr>
<tr>
<td><strong>Isight</strong></td>
</tr>
<tr>
<td>• Process Integration</td>
</tr>
<tr>
<td>• Design Optimization</td>
</tr>
<tr>
<td>• Parametric Optimization</td>
</tr>
<tr>
<td>• Six Sigma and Design of Experiments</td>
</tr>
<tr>
<td><strong>Tosca</strong></td>
</tr>
<tr>
<td>• Non-Parametric Optimization</td>
</tr>
<tr>
<td>• Structural and Fluid Flow Optimization</td>
</tr>
<tr>
<td>• Topology, Sizing, Shape, Bead Optimization</td>
</tr>
<tr>
<td><strong>fe-safe</strong></td>
</tr>
<tr>
<td>• Durability Simulation</td>
</tr>
<tr>
<td>• Low Cycle and High Cycle Fatigue</td>
</tr>
<tr>
<td>• Weld, High Temperature, Non-metallics</td>
</tr>
<tr>
<td><strong>Simpack</strong></td>
</tr>
<tr>
<td>• 3D Multibody Dynamics Simulation</td>
</tr>
<tr>
<td>• Mechanical or Mechatronic Systems</td>
</tr>
<tr>
<td>• Detailed Transient Simulation (Offline and Realtime)</td>
</tr>
<tr>
<td><strong>Realistic Human Simulation</strong></td>
</tr>
<tr>
<td>High Speed Crash &amp; Impact Noise &amp; Vibration</td>
</tr>
<tr>
<td><strong>Material Calibration</strong></td>
</tr>
<tr>
<td>Workflow Automation Design Exploration</td>
</tr>
<tr>
<td><strong>Conceptual/Detailed Design</strong></td>
</tr>
<tr>
<td>Weight, Stiffness, Stress Pressure Loss Reduction</td>
</tr>
<tr>
<td><strong>Safety Factors</strong></td>
</tr>
<tr>
<td>Creep-Fatigue Interaction Weld Fatigue</td>
</tr>
<tr>
<td><strong>Complete System Analyses</strong></td>
</tr>
<tr>
<td>(Quasi-)Static, Dynamics, NVH Flex Bodies, Advanced Contact</td>
</tr>
</tbody>
</table>
Join the Community!

How can you maximize the robust technology of the SIMULIA Portfolio?
Connect with peers to share knowledge and get technical insights

Go to www.3ds.com/slc to log in or join!

Let the SIMULIA Learning Community be Your Portal to 21st Century Innovation
Discover new ways to explore how to leverage realistic simulation to drive product innovation. Join the thousands of Abaqus and Isight users who are already gaining valuable knowledge from the SIMULIA Learning Community.

For more information and registration, visit 3ds.com/simulia-learning. Connect. Share. Spark Innovation.

©2013 Dassault Systèmes. All rights reserved.
SIMULIA SERVICES
PROVIDING HIGH QUALITY SIMULATION AND TRAINING SERVICES TO ENABLE OUR CUSTOMERS TO BE MORE PRODUCTIVE AND COMPETITIVE.

Training Schedule & Registration
We offer regularly scheduled public seminars as well as training courses at customer sites. An extensive range of courses are available, ranging from basic introductions to advanced courses that cover specific analysis topics and applications. On-site courses can be customized to focus on topics of particular interest to the customer, based on the customer's prior specification. To view the worldwide course schedule and to register for a course, visit the links below.

North American
› By Location
› By Course

International
› By Location
› By Course

Live Online Training
› Full Schedule
The software described in this documentation is available only under license from Dassault Systèmes or its subsidiaries and may be used or reproduced only in accordance with the terms of such license.

This documentation and the software described in this documentation are subject to change without prior notice.

Dassault Systèmes and its subsidiaries shall not be responsible for the consequences of any errors or omissions that may appear in this documentation.

No part of this documentation may be reproduced or distributed in any form without prior written permission of Dassault Systèmes or its subsidiaries.

© Dassault Systèmes, 2016

Printed in the United States of America.

Abaqus, the 3DS logo, and SIMULIA are trademarks or registered trademarks of Dassault Systèmes or its subsidiaries in the US and/or other countries.

Other company, product, and service names may be trademarks or service marks of their respective owners. For additional information concerning trademarks, copyrights, and licenses, see the Legal Notices in the SIMULIA User Assistance.
<table>
<thead>
<tr>
<th></th>
<th>Date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture 1</td>
<td>11/16</td>
<td>Updated for Abaqus 2017</td>
</tr>
<tr>
<td>Lecture 2</td>
<td>11/16</td>
<td>Updated for Abaqus 2017</td>
</tr>
<tr>
<td>Lecture 3</td>
<td>11/16</td>
<td>Updated for Abaqus 2017</td>
</tr>
<tr>
<td>Lecture 4</td>
<td>11/16</td>
<td>Updated for Abaqus 2017</td>
</tr>
<tr>
<td>Lecture 5</td>
<td>11/16</td>
<td>Updated for Abaqus 2017</td>
</tr>
<tr>
<td>Lecture 6</td>
<td>11/16</td>
<td>Updated for Abaqus 2017</td>
</tr>
<tr>
<td>Appendix 1</td>
<td>11/16</td>
<td>Updated for Abaqus 2017</td>
</tr>
<tr>
<td>Appendix 2</td>
<td>11/16</td>
<td>Updated for Abaqus 2017</td>
</tr>
<tr>
<td>Appendix 3</td>
<td>11/16</td>
<td>Updated for Abaqus 2017</td>
</tr>
<tr>
<td>Appendix 4</td>
<td>11/16</td>
<td>Updated for Abaqus 2017</td>
</tr>
<tr>
<td>Workshop 1</td>
<td>11/16</td>
<td>Updated for Abaqus 2017</td>
</tr>
<tr>
<td>Workshop 2</td>
<td>11/16</td>
<td>Updated for Abaqus 2017</td>
</tr>
<tr>
<td>Workshop 3</td>
<td>11/16</td>
<td>Updated for Abaqus 2017</td>
</tr>
<tr>
<td>Workshop 4</td>
<td>11/16</td>
<td>Updated for Abaqus 2017</td>
</tr>
</tbody>
</table>
Lesson 1: Introduction

Lesson content:

- Introduction
- Overview of Geotechnical Applications
- Classical and Modern Design Approaches
- Some Cases for Numerical (FE) Analysis
- Experimental Testing and Numerical Analysis
- Requirements for Realistic Constitutive Theories
Lesson 2: Physical Testing

Lesson content:

- Physical Testing
- Basic Experimental Observations
- Testing Requirements and Calibration of Constitutive Models
Lesson 3: Constitutive Models: Part 1

Lesson content:

- Stress Invariants and Spaces
- Overview of Constitutive Models
- Elasticity
- Plastic Behavior of Soils
- Mohr-Coulomb Model
- Extended Drucker-Prager Models

2 hours
Lesson 4: Constitutive Models: Part 2

Lesson content:

- Modified Drucker-Prager/Cap Model
- Critical State (Clay) Plasticity Model
- Soft Rock Plasticity Model
- Jointed Material Model
- Soil Plasticity Models - Summary
- Comments on the Numerical Implementation
- Workshop Preliminaries
- Workshop 1: Material Models for Geotechnical Applications (IA)
- Workshop 1: Material Models for Geotechnical Applications (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 5: Analysis of Porous Media

Lesson content:

- Overview
- Basic Assumptions and Effective Stress
- Stress Equilibrium and Flow Continuity
- Types of Analyses and Usage
- Saturated Example Problems
- Partially Saturated Example Problems
- Workshop 2: Pore Fluid Flow Analysis: Consolidation (IA)
- Workshop 2: Pore Fluid Flow Analysis: Consolidation (KW)

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

- Element Technology
- Geostatic States of Stress
- Pore Fluid Surface Interactions
- Element Addition and Removal
- Material Wear/Ablation through Adaptive Meshing
- Reinforced Soil Slopes
- Modeling Large Deformations in Soils
- Discrete Element Method
- DEM Model Definition
- Applications
- Tips and Suggestions
- Workshop 3: Pore Fluid Flow Analysis: Wicking (IA)
- Workshop 4: Mixing of Granular Media in a Drum Mixer

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Appendix 1: Stress Equilibrium and Fluid Continuity Equations

Appendix content:

- General equations
- Fully saturated fluid flow
- Partially saturated fluid flow
Appendix 2: Bibliography of Geotechnical Example Problems

Appendix content:

- Abaqus Example Problems
- Abaqus Benchmark Problems

This appendix provides a list of Abaqus Example and Benchmark Problems that show the use of capabilities for geotechnical modeling.
Appendix 3: Infinite Domains

Appendix content:

- Infinite Domains
Appendix 4: Hydraulic Fracture

Appendix content:

- Hydraulic Fracture
- Coupled Pore Pressure-Displacement Cohesive Elements
- Hydraulic Fracture with XFEM
- Enabling Technologies for a 1D Borehole Model
- Fluid Pipe Elements
- Fluid Pipe Connectors Elements
- Input file example for fluid pipe and fluid connector
- Coupling Fluid Pipe Elements to Continuum and Cohesive Elements
- Automatic Application of Mechanical Distributed Pressure Load
- Automatic Application of Nodal Pressures to Fractures
- Hydraulic Fracture: XFEM and Surface Tie Constraints
- Hydraulic Fracture: Cohesive Elements and Surface Tie Constraints
- Consolidation Analysis: Embedded Fluid Pipe Element
- Multistage Injection Process Using Valve Connectors
- “Submodeling” with Fluid Pipe Connectors
- Modeling Tips
- Limitations