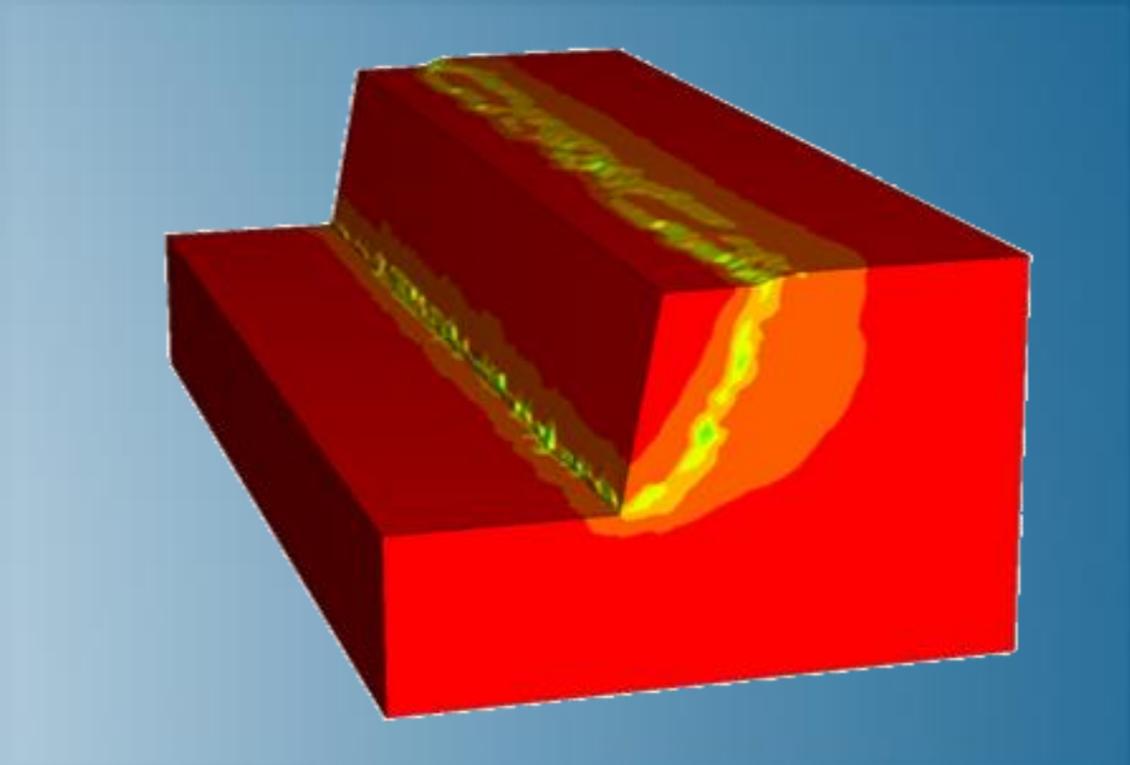


# Analysis of Geotechnical Problems with Abaqus

Abaqus 2018



**3DEXPERIENCE**<sup>®</sup>



# About this Course

## 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



2 days

# Day 1

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- ▶ 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

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- ▶ 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*)

## Additional Material

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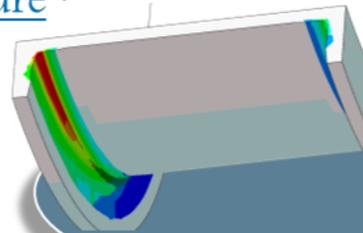
- ▶ Appendix 1      Stress Equilibrium and Fluid Continuity Equations
- ▶ Appendix 2      Bibliography of Geotechnical Example Problems
- ▶ Appendix 3      Infinite Domains
- ▶ Appendix 4      Hydraulic Fracture

# SIMULIA

- ▶ SIMULIA is the Dassault Systèmes brand for Realistic Simulation solutions
- ▶ Portfolio of established, best-in-class products
  - Abaqus, Isight, Tosca, fe-safe, Simpack

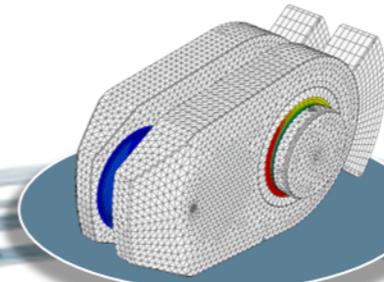
## Design Optimization: Tosca Structure \*

Simulation-driven design refinement to improve performance



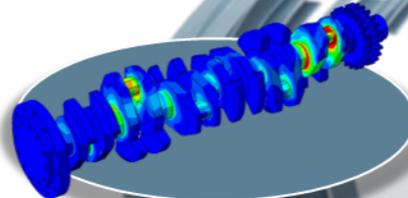
## Durability Assessment: fe-safe \*

Accurate life estimation to achieve certification



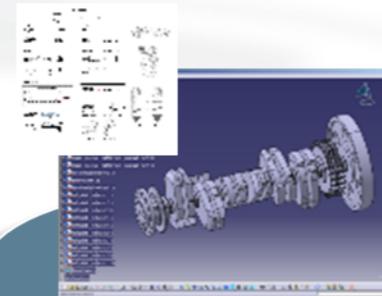
## FEA Stress Analysis: Abaqus \*

Detailed stress analysis using extracted load history from MBS



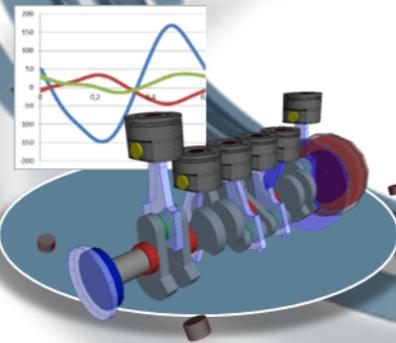
## CAD Geometry: CATIA

Fully parameterized 3D geometry; FEA model generation via associative interface



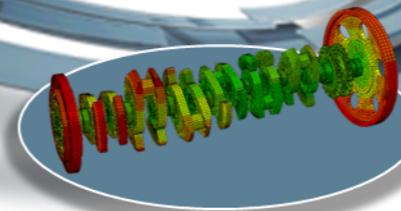
## Multibody Simulation: Simpack

System analysis to extract virtual load history of complete working cycle



## Mesh Calibration: Isight \*

Automated mesh calibration; sufficient mesh quality for accurate results

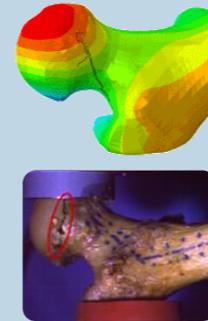


\* Included in extended licensing pool

# SIMULIA's Power of the Portfolio

## Abaqus

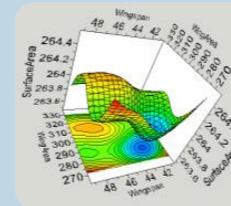
- Routine and Advanced Simulation
- Linear and Nonlinear, Static and Dynamic
- Thermal, Electrical, Acoustics
- Extended Physics through Co-simulation
- Model Preparation and Visualization



**Realistic Human Simulation  
High Speed Crash & Impact  
Noise & Vibration**

## Isight

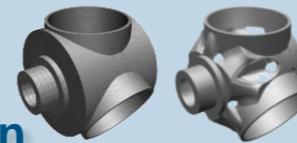
- Process Integration
- Design Optimization
- Parametric Optimization
- Six Sigma and Design of Experiments



**Material Calibration  
Workflow Automation  
Design Exploration**

## Tosca

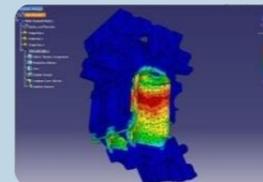
- Non-Parametric Optimization
- Structural and Fluid Flow Optimization
- Topology, Sizing, Shape, Bead Optimization



**Conceptual/Detailed Design  
Weight, Stiffness, Stress  
Pressure Loss Reduction**

## fe-safe

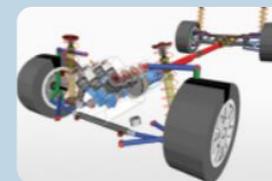
- Durability Simulation
- Low Cycle and High Cycle Fatigue
- Weld, High Temperature, Non-metallics



**Safety Factors  
Creep-Fatigue Interaction  
Weld Fatigue**

## Simpack

- 3D Multibody Dynamics Simulation
- Mechanical or Mechatronic Systems
- Detailed Transient Simulation (Offline and Realtime)



**Complete System Analyses  
(Quasi-)Static, Dynamics, NVH  
Flex Bodies, Advanced  
Contact**

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 SIMULIA

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- > By Course

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# Revision Status

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Lecture 1	11/17	Updated for Abaqus 2018
Lecture 2	11/17	Updated for Abaqus 2018
Lecture 3	11/17	Updated for Abaqus 2018
Lecture 4	11/17	Updated for Abaqus 2018
Lecture 5	11/17	Updated for Abaqus 2018
Lecture 6	11/17	Updated for Abaqus 2018
Appendix 1	11/17	Updated for Abaqus 2018
Appendix 2	11/17	Updated for Abaqus 2018
Appendix 3	11/17	Updated for Abaqus 2018
Appendix 4	11/17	Updated for Abaqus 2018
Workshop 1	11/17	Updated for Abaqus 2018
Workshop 2	11/17	Updated for Abaqus 2018
Workshop 3	11/17	Updated for Abaqus 2018
Workshop 4	11/17	Updated for Abaqus 2018

# 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



45 minutes

# Lesson 2: Physical Testing

## *Lesson content:*

- ▶ Physical Testing
- ▶ Basic Experimental Observations
- ▶ Testing Requirements and Calibration of Constitutive Models



30 minutes

# 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.



2.5 hours

# 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.



2.5 hours

# Lesson 6: Modeling Aspects

## ***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 3: Pore Fluid Flow Analysis: Wicking (KW)
- ▶ Workshop 4: Mixing of Granular Media in a Drum Mixer



3 hours



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



30 minutes

# 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



5 minutes

# Appendix 3: Infinite Domains

## *Appendix content:*

- ▶ Infinite Domains



30 minutes

# 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



3 hours