



AD FALCON API Manual

What is FALCON?

Javad Ghorbani

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Contents

1	What is FALCON?	3
1.1	About This Manual	3
1.2	Highlights	4
1.3	Table of Contents	4
1.4	Navigation Structure	4
1.4.1	Document map	4
1.4.2	PDF index	8



Welcome to the official API and theory manual for FALCON, a state-of-the-art finite element simulation engine for advanced geotechnical engineering and scientific applications. FALCON is available both through a graphical user interface and as a programmatic engine that reads structured input files and produces numerical outputs. This manual defines the underlying input/output specification—the **FALCON API**—which serves as the complete interface contract for all interaction methods (GUI, command-line, and programmatic access), and explains the theory behind its models and solution procedures.

Quick links: - [Introduction](#) - [Examples](#) - [Materials](#)

1 What is FALCON?

FALCON (Finite Element Analysis Leveraging Computational Optimization for Nonlinear Geomechanics) — also known as **AD FALCON** or **Artemis Dev FALCON** — is a state-of-the-art simulation framework engineered to solve the most demanding challenges in geotechnical engineering and applied sciences. Developed by Artemis Dev, FALCON provides a unified environment for simulating the complex, coupled interactions between solids, pore water, and pore air under both static and dynamic conditions. FALCON supports 2D (plane strain, axisymmetric) and 3D analyses across all coupling levels.

At its core, FALCON is built upon the robust foundation of extended Biot’s theory of soil dynamics for unsaturated soils. This allows for a sophisticated, fully coupled hydro-mechanical analysis that captures the real-world behavior of soils with unparalleled accuracy.

1.1 About This Manual

This is the **FALCON API & Theory Manual**—the authoritative specification for the FALCON solver engine. This manual serves as the complete reference for the **FALCON API**, defining the structured input/output interface used by the GUI, command-line executable, and programmatic integrations.

This manual includes:

- **Input File Structure & Syntax:** Complete documentation of all input sections, keywords, parameters, and their syntax requirements. The Model Setup & Inputs section provides detailed syntax for every input file component.
- **Error Dictionary:** Comprehensive reference for all error and warning codes ([IR-XXXX], [LA-XXXX], [MF-XXXX], etc.) with explanations, causes, and resolution steps. This is essential for debugging input files and understanding validation messages.
- **Material Model Parameters:** Complete specification of constitutive model parameters, UMAT integration points, and material property definitions.
- **Output Variables & State Variables:** Documentation of all available output quantities, state variables, and their interpretation.
- **Theoretical foundations:** Governing equations, balance laws, effective stress, and multi-phase coupling formulations.

- **Numerical methods:** Discretization approaches, weak forms, FE matrices, time integration schemes, and stability criteria.
- **Analysis scopes:** Detailed explanation of Uncoupled, Coupled (saturated), and Fully Coupled (unsaturated) formulations, their degrees of freedom, and assumptions.
- **Verification examples:** Canonical benchmark problems with references, expected response trends, and validation results that demonstrate proper API usage.

1.2 Highlights

- **Fully Coupled Unsaturated Analysis:** Unlike traditional geotechnical software limited to saturated conditions, FALCON uniquely provides fully coupled hydro-mechanical analysis for unsaturated soils—essential for climate change impact assessment and arid region engineering.
- **Extended Biot's Theory Implementation:** Industry-leading implementation of extended Biot's theory for unsaturated soil dynamics, enabling accurate simulation of seismic response, wave propagation, and dynamic loading across all saturation states—beyond what PLAXIS or FLAC offer.
- **Unified Multi-Scale Framework:** Single-platform solution integrating static, consolidation, and dynamic analyses across uncoupled, saturated, and unsaturated regimes—eliminating the need for multiple software packages like PLAXIS + FLAC combinations.
- **Advanced Constitutive Modeling:** Comprehensive library of sophisticated soil models (Mohr-Coulomb, GCC, CASM, SANISAND) with full UMAT integration for custom material development—surpassing the material libraries of traditional geotechnical software.
- **Climate Change Engineering:** Specialized capabilities for predicting climate change impacts on infrastructure, including unsaturated soil behavior under extreme weather conditions and long-term environmental changes—unique in geotechnical simulation.
- **Research-to-Practice Bridge:** Mathematically rigorous implementation validated against benchmark problems, enabling direct application of cutting-edge research in practical engineering projects with confidence unmatched by conventional tools.

1.3 Table of Contents

To begin using **FALCON**, use the navigation sidebar or refer to the structured file hierarchy below. Each entry links to the corresponding markdown file in the docs repository.

1.4 Navigation Structure

1.4.1 Document map

- [Home](#)
- **Theory**

- Introduction
- Uncoupled Analysis
- Coupled Analysis
- Fully Coupled Analysis
- Simulation Modes

- **Inputs**

- Input file Structure
- CLI Paths & Working Directory
- Postprocessing Outputs
- Include & Modular Input Files
- Analysis Type
- State Variables
- Nodes
- Materials
- Elements
- Boundary Conditions
- MPC Constraints (MPCConstraints)
- Releasing Restrained Dofs and Adding Restrained Dofs Mid analysis
- LoadTypes
- StressBoundary
- Discharge
- Steps
- Linear Solvers
- Implicit Time Integration
- Explicit and IMEX Time Integration
- Fixed Time Increment
- Automatic time incrementation
- Checkpoint & Restart
- InitialAssignment
- PostStep actions
- RigidBody
- Contact Pairs
- Prescribed Values and Dirichlet Boundary Condition
- OutputVar
- BodyForce
- Tie and Untie DoFs
- Point & Line State Output
- Special Outputs
- Activation and Deactivation of Elements
- Step Materials



- Infinite Elements
- Sponge Layer
- Perfectly Matched Layer (PML)
- ALE Mesh Smoothing
- **Material models**
 - Syntax & Conventions
 - **Constitutive Equation**
 - * Overview
 - * Linear Elasticity (Isotropic)
 - * Orthotropic Elasticity
 - * MohrModel
 - * GCCModel
 - * CASMModel
 - * MITS1Model
 - * SANICLAYModel
 - * SSLSMModel
 - * SANISANDMModel
 - * NorSandModel
 - * NonlinearElasticModel
 - * UMAT Development
 - **SWRC**
 - * Overview
 - * van Genuchten
 - * Fredlund & Xing
 - * Brooks & Corey
 - * Hysteretic model
 - **Permeability**
 - * Overview
 - * Constant Permeability
 - * Void Ratio Affected Constant Permeability
 - * van Genuchten
 - * Brooks-Corey
 - * k_e Multiplier
 - * Anisotropic Permeability
 - **Phase Properties**
 - * Overview
 - **Effective Stress**
 - * Ghorbani and Kodikara



• Verification & Demonstrations**– Uncoupled Analyses***** Elasticity & Boussinesq**

- Plane Strain - Elasticity and Boussinesq's solution
- Plane Strain - Element Type Comparison
- Plane Strain - Orthotropic Elasticity
- Axisymmetric models - Elasticity and Boussinesq's solution
- Three-dimensional - Elasticity and Boussinesq's solution
- Checkpoint & Restart Example

*** Domain Truncation**

- Infinite Elements for Far-Field Truncation
- PML Impulse Benchmark (Uncoupled)

*** Load Type Demonstrations**

- Demonstrative Examples of Load and Propagation Options
- Demonstrative Examples of Prescribing Displacement

*** Soil Dynamics**

- One-Dimensional Wave Propagation in a Soil Column

*** Material models**

- Rigid footing Modeling using Nonlinear Elastic Model
- Rigid footing Modeling using Cam Clay Elasticity Model
- Rigid footing with Mohr-Coulomb Model
- Sensitivity Analysis - Auto-Increment Parameters
- Mohr-Coulomb Model against Prandtl solution
- Rigid footing with MCC Model
- Rigid footing with CASM Model
- Rigid footing with SSLSM Model

*** Contact**

- Elastic Contact

– Coupled Analyses

- * Terzaghi's One-dimensional Consolidation
- * Infinite Elements for Far-Field Truncation (Coupled)
- * PML Impulse Benchmark (Coupled)
- * Body Force Application in Coupled Analyses
- * Elastodynamics of saturated soils
- * Large Deformation
- * Effective-Stress-Based Undrained Bearing Capacity of a Flexible Strip Footing
- * Undrained cavity expansion using MCC model

- * [Rigid footing with MCC Model - Loading Rate Effects](#)
- * [Cyclic Loads](#)
- **Fully Coupled Analyses**
 - * [One-dimensional Wave Propagation in Unsaturated Soil Column](#)
 - * [IMEX Benchmark \(Fully Coupled, 3D\)](#)
 - * [Infinite Elements for Far-Field Truncation \(Fully Coupled\)](#)
 - * [PML Impulse Benchmark \(Fully Coupled\)](#)
 - * [Gravity-Driven Initialization and Establishing Hydrostatic Pressures in Fully Coupled Analyses of Unsaturated Soils](#)
 - * [Failure Analysis of Unsaturated Soils using Mohr–Coulomb Model](#)
 - * [Rigid footing with MCC Model - Suction Effects](#)
- **ML & UQ**
 - * [Parametric Studies & Uncertainty Quantification](#)
 - * [Uncertainty Quantification for Boussinesq Foundation](#)
- **Appendices**
 - [Error Dictionary](#)

1.4.2 PDF index

Page	PDF
Home	index.pdf
Introduction	theoryintroduction.pdf
Uncoupled Analysis	uncoupledtheory.pdf
Coupled Analysis	coupledtheory.pdf
Fully Coupled Analysis	fullycoupledtheory.pdf
Simulation Modes	simmodes.pdf
Input file Structure	inputfilestructure.pdf
CLI Paths & Working Directory	cli-paths.pdf
Postprocessing Outputs	postprocessing.pdf
Include & Modular Input Files	include.pdf
Analysis Type	analysis-properties.pdf
State Variables	statevariables.pdf
Nodes	nodes.pdf
Materials	materials.pdf
Elements	elements.pdf
Boundary Conditions	boundaryconditions.pdf
MPC Constraints (MPCConstraints)	mpcconstraints.pdf

Page	PDF
Releasing Restrained Dofs and Adding Restrained Dofs Mid analysis	readddofs.pdf
LoadTypes	loadtypes.pdf
StressBoundary	stressboundary.pdf
Discharge	dischargeboundary.pdf
Steps	steps.pdf
Linear Solvers	solvers.pdf
Implicit Time Integration	implicit-time-integration.pdf
Explicit and IMEX Time Integration	explicit-imex.pdf
Fixed Time Increment	fixedtimeincrement.pdf
Automatic time incrementation	autoincrement.pdf
Checkpoint & Restart	checkpoint-restart.pdf
InitialAssignment	initialassignment.pdf
PostStep actions	poststeps.pdf
RigidBody	rigidbody.pdf
Contact Pairs	contact.pdf
Prescribed Values and Dirichlet Boundary Condition	prescribed.pdf
OutputVar	outputvars.pdf
BodyForce	bodyforce.pdf
Tie and Untie DoFs	tieuntie.pdf
Point & Line State Output	pointstateoutput.pdf
Special Outputs	specialoutputs.pdf
Activation and Deactivation of Elements	activationdeactivation.pdf
Step Materials	step-materials.pdf
Infinite Elements	infinite-elements.pdf
Sponge Layer	sponge.pdf
Perfectly Matched Layer (PML)	pml.pdf
ALE Mesh Smoothing	alemeshsmoothing.pdf
Syntax & Conventions	materialmodels-syntax.pdf
Overview	constitutive-equation-introduction.pdf
Linear Elasticity (Isotropic)	elasticity.pdf
Orthotropic Elasticity	orthotropic.pdf
MohrModel	mohr.pdf
GCCModel	gccmodel.pdf
CASModel	casmodel.pdf
MITS1Model	mits1model.pdf
SANICLAYModel	saniclaymodel.pdf

Page	PDF
SSLSMModel	sslsmodel.pdf
SANISANDMMModel	sanisandmodel.pdf
NorSandModel	norsandmodel.pdf
NonlinearElasticModel	nonlinearelastic.pdf
UMAT Development	umat-development.pdf
Overview	swrcintro.pdf
van Genuchten	swrcvg.pdf
Fredlund & Xing	swrcfx.pdf
Brooks & Corey	swrcbc.pdf
Hysteretic model	swrchys.pdf
Overview	permintro.pdf
Constant Permeability	permconstant.pdf
Void Ratio Affected Constant Permeability	permvoidratio.pdf
van Genuchten	permg.pdf
Brooks-Corey	permcb.pdf
k _e Multiplier	permke.pdf
Anisotropic Permeability	permanisotropic.pdf
Overview	phaseproperties.pdf
Ghorbani and Kodikara	gk2024.pdf
Plane Strain - Elasticity and Boussinesq's solution	Elasticityand\protect\penalty\z@{}Boussinesqsolution.pdf
Plane Strain - Element Type Comparison	elementcomparisonboussinesq.pdf
Plane Strain - Orthotropic Elasticity	orthotropicelasticityboussinesq.pdf
Axisymmetric models - Elasticity and Boussinesq's solution	axisymmetricmodelselasticityandboussinesqsolution.pdf
Three-dimensional - Elasticity and Boussinesq's solution	threedmodelselasticityandboussinesqsolution.pdf
Checkpoint & Restart Example	checkpoint-restart-example.pdf
Infinite Elements for Far-Field Truncation	infinite-elements-uncoupled.pdf
PML Impulse Benchmark (Uncoupled)	pml-uncoupled.pdf
Demonstrative Examples of Load and Propagation Options	demonstrativeexamplesofloadandpropagationoptions.pdf
Demonstrative Examples of Prescribing Displacement	demosntartiveexamplesofprescribingdisplacement.pdf
One-Dimensional Wave Propagation in a Soil Column	soildynamics_uncoupled.pdf
Rigid footing Modeling using Nonlinear Elastic Model	rigidfootingmodelingusingnonlinearelasticmodel.pdf

Page	PDF
Rigid footing Modeling using Cam Clay Elasticity Model	rigidfootingmodelingusingcamclayelasticitymodel.pdf
Rigid footing with Mohr–Coulomb Model	rigidfootingmohr.pdf
Sensitivity Analysis - Auto-Increment Parameters	autoincrement_sensitivity.pdf
Mohr–Coulomb Model against Prandtl solution	rigidfootingautoincmohr.pdf
Rigid footing with MCC Model	rigidfootinggcc.pdf
Rigid footing with CASM Model	rigidfootingmodelingusingcasmmodel.pdf
Rigid footing with SSLSM Model	rigidfootingssls.pdf
Elastic Contact	elasticcontact.pdf
Terzaghi's One-dimensional Consolidation	1dconsolidation.pdf
Infinite Elements for Far-Field Truncation (Coupled)	infinite-elements-coupled.pdf
PML Impulse Benchmark (Coupled)	pml-coupled.pdf
Body Force Application in Coupled Analyses	bodyforceapplicationincoupledanalysis.pdf
Elastodynamics of saturated soils	dynamicsaturated.pdf
Large Deformation	largedeformationcoupled.pdf
Effective-Stress-Based Undrained Bearing Capacity of a Flexible Strip Footing	effstressundrainedbearing.pdf
Undrained cavity expansion using MCC model	undrainedcavityexpansionusingmccmodel.pdf
Rigid footing with MCC Model - Loading Rate Effects	rigidfootingsaturatedmcc.pdf
Cyclic Loads	cyclicload.pdf
One-dimensional Wave Propagation in Unsaturated Soil Column	1dunsaturatedsoildynamics.pdf
IMEX Benchmark (Fully Coupled, 3D)	imex-fullycoupled.pdf
Infinite Elements for Far-Field Truncation (Fully Coupled)	infinite-elements-fullycoupled.pdf
PML Impulse Benchmark (Fully Coupled)	pml-fullycoupled.pdf
Gravity-Driven Initialization and Establishing Hydrostatic Pressures in Fully Coupled Analyses of Unsaturated Soils	bodyforceunsat.pdf
Failure Analysis of Unsaturated Soils using Mohr–Coulomb Model	mohrunsat.pdf

Page	PDF
Rigid footing with MCC Model - Suction Effects	rigidfootingunsaturatedmcc.pdf
Parametric Studies & Uncertainty Quantification	parametric-studies.pdf
Uncertainty Quantification for Boussinesq Foundation	boussinesq-uncertainty-quantification.pdf
Error Dictionary	errordictionary.pdf

