AD FALCON API Manual

What is FALCON?

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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.

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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

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