AD FALCON API Manual

Coupled Analysis: Body Force Application

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Contents

1 Coupled Analysis: Body Force Application

1.1 Overview

The example show how to apply body force in a coupled analysis and generate hydrostatic pressure.

1.2 Input File Name

fem_coupled_body_force.txt

Key tip for coupled analysis:
Use a sufficiently large time step so that the simulation rapidly reaches steady-state, effectively damping out any consolidation/transient effects.

1.3 Step Definitions

```
% Step Definitions
@Step 1:
@@SolverType: Direct
@@StartStep: 0
@@StepTime: 1.0e9                <-- Large time step to damp consolidation
@@NumberSteps: 10.0
@@OutputInterval: 1
@@OutputTypes: Displacement EffStress Strain PW
@@UL: No
@@ErrorTarget: 1.0e-1
@@SimMode: Static
%%%

% Body Force: Apply soil + water weight
Force 0.0 -9.81 0.0                % Solid weight (gravity)
WaterContribution 0.0 -9.81 0.0    % Water weight (gravity)
AirContribution 0.0 0 0.0          % Air weight, typically zero in
saturated case
ElementIDs All
LoadType Ramp Step 1
StartStep 1
Propagate: FinalStep 1
%%%
```

1.4 Notes

- Apply **solid and water weights** as body forces to all elements in the model.
- The **large time step** (`StepTime: 1.0e9`) prevents simulation of transient consolidation—initial conditions will immediately reflect hydrostatic equilibrium.
- Useful for initializing pore pressure and effective stress fields in coupled analyses.

1.5 Verification

Given:

- Solid density: $\rho_s = 2700$ kg/m³
- Water density: $\rho_w = 997$ kg/m³
- Gravity: $g = 9.81$ m/s²
- Void ratio: $e = 0.35 \rightarrow$ Porosity: $n = \frac{e}{1+e} = 0.259$
- Saturation: $S_w = 1.0$
- Depth: $H = 10$ m

Total unit weight (γ_{total}):

$$\gamma_{total} = (1-n)\cdot\rho_s\cdot g + n\cdot S_w\cdot\rho_w\cdot g \gamma_{total} = (1-0.259)\cdot 2700\cdot 9.81 + 0.259\cdot 997\cdot 9.81 = 22,155.7 \text{ N/m}^3 \quad (1)$$

At 10 m depth:

- **Total stress**:

$$\sigma_{total} = \gamma_{total} \cdot H = 22,155.7 \cdot 10 = \mathbf{221.56} \text{ kPa} \quad (2)$$

- **Pore water pressure**:

$$u = \rho_w \cdot g \cdot H = 997 \cdot 9.81 \cdot 10 = \mathbf{97.81} \text{ kPa} \quad (3)$$

- **Effective stress**:

$$\sigma' = \sigma_{total} - u = 221.56 - 97.81 = \mathbf{123.75} \text{ kPa} \quad (4)$$

***

1.6 Results

At the end of this step, the following should be plotted:

- **Pore Water Pressure vs. Depth** (should be hydrostatic profile)
- **Vertical Effective Stress vs. Depth** (should reflect total stress minus pore pressure)
- **Total Stress vs. Depth**

> **Note:** In **FALCON**, compressive stresses are considered **negative**, while **pore fluid flow is considered positive** when **compressive**.

1.6.1 Stress Profiles

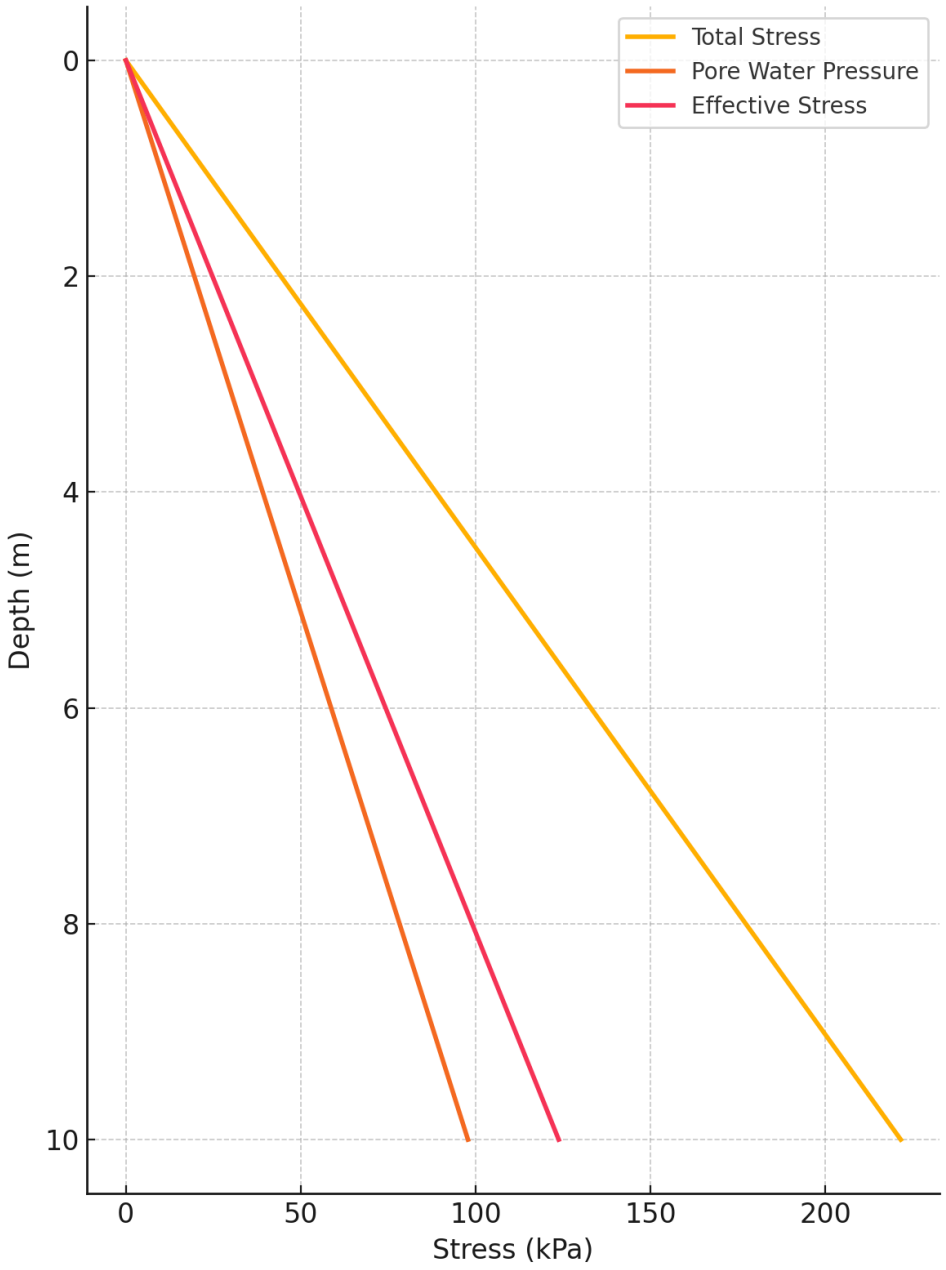

Figure 1: Stress Profiles vs Depth