AD FALCON API Manual

Element Type Comparison

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1 Element Type Comparison

1.1 Problem Description

This validation case involves the same 2×2 m foundation model analyzed using Plane Strain Uncoupled (PLUnCoupled) mechanics as described in Elasticity and Boussinesq's Solution. A uniform pressure of 100 kPa is applied over a central 0.1 m width. The objective of this study is to compare the accuracy and computational performance of different element types when solving the same problem.

1.1.1 Objective

Compare the time accuracy in terms of predicted displacement at the center of the loaded area using four different element types: - **N4P4**: Linear quadrilateral elements with 2×2 Gauss integration (4 nodes, 4 integration points) - **N8P9**: Quadratic quadrilateral elements with 9 integration points (8 nodes, 9 integration points) - **N3P3**: Linear triangular elements with 3-point integration (3 nodes, 3 integration points) - **N6P6**: Quadratic triangular elements with 6-point integration (6 nodes, 6 integration points)

1.2 Model Setup

The FEM model setup, geometry, boundary conditions, material properties, and step definitions are identical to those described in Elasticity and Boussinesq's Solution. The only difference is the element type used in each analysis: N4P4, N8P9, N3P3, and N6P6 (separate analyses for each element type).

1.3 Element Type Specifications

1.3.1 N4P4 - Linear Quadrilateral

- **Nodes**: 4 corner nodes
- **Integration Points**: 4 (2×2 Gauss integration)
- **Shape Functions**: Bilinear
- **Element Type Code**: `N4P4`

1.3.2 N8P9 - Quadratic Quadrilateral

- **Nodes**: 8 nodes (4 corners + 4 mid-side nodes)
- **Integration Points**: 9 (3×3 Gauss integration)
- **Shape Functions**: Biquadratic
- **Element Type Code**: `N8P9`
- **Note**: Only corner nodes are principal nodes (carry pressure DOFs in coupled analyses)

1.3.3 N3P3 - Linear Triangle

- **Nodes**: 3 corner nodes

- **Integration Points**: 3 (Gauss-Legendre)
- **Shape Functions**: Linear
- **Element Type Code**: `N3P3`

1.3.4 N6P6 - Quadratic Triangle

- **Nodes**: 6 nodes (3 corners + 3 mid-side nodes)
- **Integration Points**: 6
- **Shape Functions**: Quadratic
- **Element Type Code**: `N6P6`
- **Note**: Only vertex nodes are principal nodes (carry pressure DOFs in coupled analyses)

1.4 Input Files

The following input files demonstrate the same problem solved with different element types:

- N4P4 - Linear Quadrilateral
- N8P9 - Quadratic Quadrilateral
- N3P3 - Linear Triangle
- N6P6 - Quadratic Triangle

1.5 Results Comparison

1.5.1 Displacement at Center

The vertical displacement u_y at the center of the loaded area (x = 0, y = 2.0 m) is compared across all element types.

1.5.2 Comparison Table

The following table summarizes the predicted vertical displacement at the center for each element type:

Element Type	Number of Elements	Nodes per Element	Integration Points	Predicted Displacement (m)	Computational Time (s)	Time per Element (ms)
N4P4	1,742	4	4	0.000183	5.18	2.97
N8P9	1,742	8	9	0.000184	25.56	14.67
N3P3	3,600	3	3	0.000180	5.47	1.52
N6P6	3,600	6	6	0.000184	30.57	8.49