



AD FALCON API Manual

Infinite Elements for Far-Field Truncation (Uncoupled Analysis)

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Contents

1	Infinite Elements for Far-Field Truncation (Uncoupled Analysis)	3
1.1	Input Files	3
1.2	Problem Description	3
1.3	Model Setup	3
1.3.1	Domain Configuration	3
1.3.2	Geometry	3
1.3.3	Analysis Type	4
1.3.4	Material Properties	5
1.3.5	Step Definition	5
1.3.6	Stress Boundary (Loading)	5
1.4	Infinite Element Configuration	5
1.4.1	Configuration Parameters	6
1.5	Results	7
1.5.1	Settlement Profile at Load Center	7
1.5.2	Vertical Displacement at Various Depths	8
1.5.3	Settlement Profile at Footing Edges	8
1.6	Quantitative Comparison	8
1.7	Runtime Comparison	8
1.8	Ray Length Sensitivity	9
1.9	Key Observations	9
1.10	Comparison with Other Boundary Treatments	12

1 Infinite Elements for Far-Field Truncation (Uncoupled Analysis)

1.1 Input Files

- [Small domain with infinite elements](#)
- [Small truncated domain](#)
- [Medium truncated domain](#)
- [Large truncated domain \(reference\)](#)

1.2 Problem Description

This example demonstrates the use of **mapped infinite elements** to truncate an unbounded domain in a plane strain uncoupled (solid-only) static analysis.

Purpose: show how a small near-field mesh augmented with infinite elements reproduces the displacement (settlement) field of a much larger truncated domain, and to quantify the boundary-constraint error when the same small domain is solved with standard fixed truncation boundaries.

What is compared (same loading and material in all cases): - A **2×2 m** domain with **infinite elements** on the left/right/bottom (small near-field model) - A **2×2 m** domain with **fixed truncation boundaries** (small truncated) - A **4×4 m** domain with **fixed truncation boundaries** (medium truncated) - An **8×8 m** domain with **fixed truncation boundaries** (large truncated reference)

1. A **small domain with infinite elements** attached to the boundaries
2. **Truncated domains** of various sizes without infinite elements

The analysis shows that a small computational domain augmented with infinite elements can approximate the response of a much larger (effectively semi-infinite) domain, significantly reducing computational cost.

1.3 Model Setup

1.3.1 Domain Configuration

Figure: Small computational domain (2×2 m) with infinite elements attached to the left, right, and bottom boundaries. The infinite elements extend the domain to represent a semi-infinite half-space.

1.3.2 Geometry

Four models are compared:

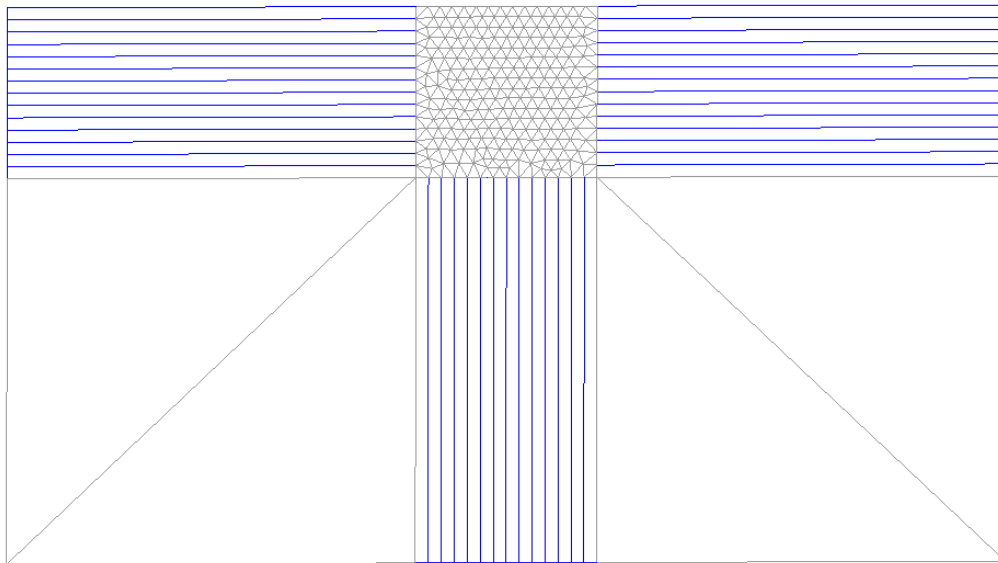


Figure 1: Domain with infinite elements

Model	Domain Size	Boundary Treatment	Nodes
Small + Infinite	2 × 2 m	Infinite elements on left, right, and bottom	~1,000
Small Truncated	2 × 2 m	Fixed boundaries	~1,000
Medium Truncated	4 × 4 m	Fixed boundaries	~4,000
Large Truncated	8 × 8 m	Fixed boundaries (reference)	~15,000

All models apply a uniform pressure over a strip of width $2a = 0.67$ m centered on the top surface.

For the dataset shown in this page (load-scaled), NormalPressures = -10000 (i.e., 10 kPa).

1.3.3 Analysis Type

```
% AnalysisType
PLNonCoupled
%%%
```

1.3.4 Material Properties

Linear elastic material (soft soil for visualization of deformation):

```
% Materials
Mat1
@Mech: Elastic YoungsModulus 1.0e5 PoissonRatio 0.3
@PhaseChar: Solid rhos 2650.0
%%%
```

1.3.5 Step Definition

Static analysis with ramp loading:

```
% Step Definitions
@Step 1:
@@SolverType: Direct
@@StartStep: 0
@@NumberSteps: 10
@@StepTime: 1.0
@@OutputControlType: ByStep
@@OutputControlValue: 1.0
@@OutputTypes: Displacement EffStress
@@SimMode: Static
%%%
```

1.3.6 Stress Boundary (Loading)

Uniform pressure applied on elements along the top surface:

```
% Stress Boundary
@Pressure: ElemId 11 Edgenodes 911 921 930
NormalPressures -10000 -10000 -10000
TangentialPressures 0.0 0.0 0.0
LoadType Ramp Step 1
Propagate: Yes
...
%%%
```

1.4 Infinite Element Configuration

Infinite elements are attached to the left, right, and bottom boundaries of the small domain:

```

% Infinite Elements
@Boundary Left
  @Type: TRI6
  @Topology: Strip
  @Material: Mat1
  @Nodes: 757 765 773 794 811 834 858 882 904 926 943 960 972 979 984
  @ExteriorPoint: -2.0 1.0
  @InteriorPoint: 0.5 1.0
  @RayLength: 4.5
  @ApplyInfinityBC: Yes
%%%

@Boundary Right
  @Type: TRI6
  @Topology: Strip
  @Material: Mat1
  @Nodes: 1 5 14 33 61 95 135 185 246 314 387 469 558 659 758
  @ExteriorPoint: 4.0 1.0
  @InteriorPoint: 1.5 1.0
  @RayLength: 4.5
  @ApplyInfinityBC: Yes
%%%

@Boundary Bottom
  @Type: TRI6
  @Topology: Strip
  @Material: Mat1
  @Nodes: 757 660 559 470 388 315 247 186 136 96 62 34 15 6 1
  @ExteriorPoint: 1.0 -2.0
  @InteriorPoint: 1.0 0.5
  @RayLength: 4.5
  @ApplyInfinityBC: Yes
%%%

```

1.4.1 Configuration Parameters

Parameter	Description
@Type: TRI6	Interior mesh uses 6-node quadratic triangles
@Topology: Strip	Generates QUAD8 infinite elements with parallel rays (for straight boundaries)
@Nodes	Corner nodes along the boundary polyline; mid-side nodes detected automatically
@ExteriorPoint, @InteriorPoint	Define the outward direction

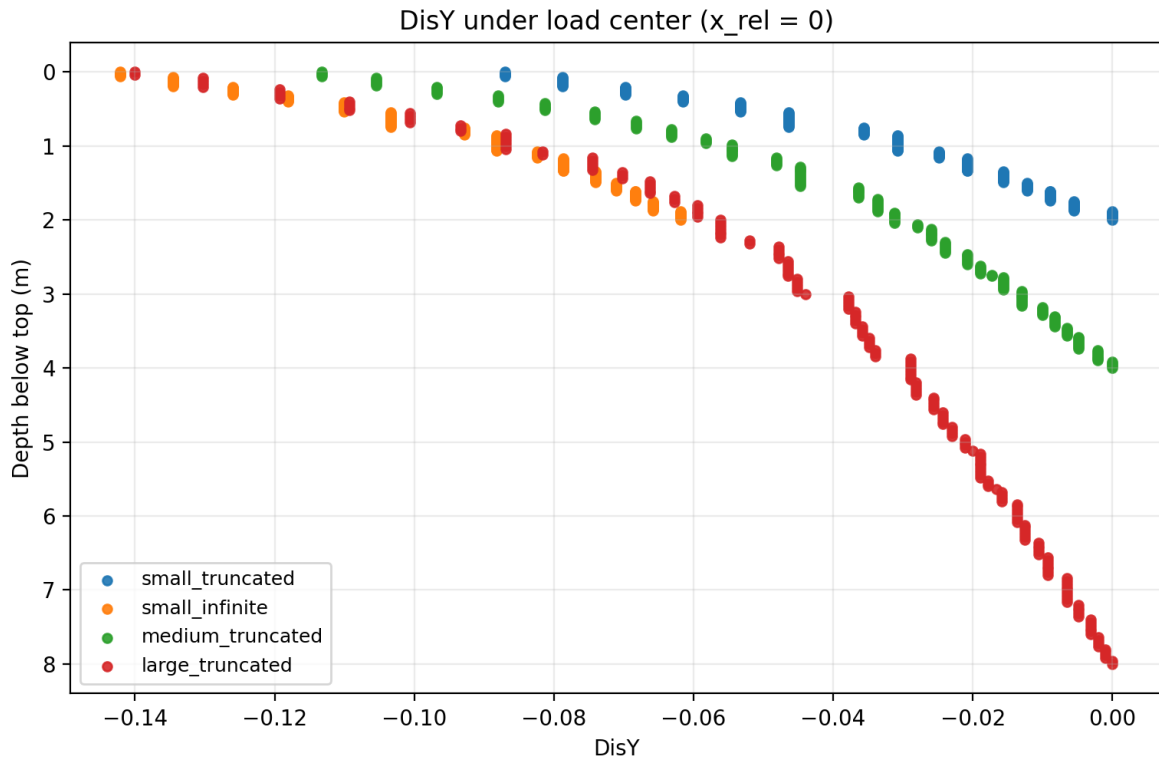


Figure 2: Figure 1: Settlement profile at load center

Parameter	Description
<code>@@RayLength: 4.5</code>	Physical distance to direction nodes (~2.25× domain width)
<code>@@ApplyInfinityBC: Yes</code> <code>@@DisX, @@DisY (optional)</code>	Apply Dirichlet conditions at far-field nodes Prescribed far-field displacement values. If omitted for strip topology, the solver applies a default roller-style infinity BC (normal component only) to avoid over-constraining the far field.

1.5 Results

1.5.1 Settlement Profile at Load Center

The figure below compares the vertical displacement profile directly beneath the load center for all four models:

Figure 1: Settlement (vertical displacement) vs. depth beneath the load center. The small domain with infinite elements (blue) closely matches the large truncated reference

domain (red) throughout the depth. The truncated domains without infinite elements (orange, green) significantly underestimate the settlement. The profiles are shown as discrete samples (scatter markers).

1.5.2 Vertical Displacement at Various Depths

The figure below shows horizontal profiles of vertical displacement at depths of 0.01, 0.5, 1.0, and 1.5 m below the surface:

Figure 2: Vertical displacement vs. normalized horizontal position x/a at four depths. Dashed vertical lines mark the footing edges ($x/a = \pm 1$). The infinite element solution (blue) captures the displacement distribution of the large reference domain (red), while the smaller truncated domains show constrained boundary effects.

1.5.3 Settlement Profile at Footing Edges

Figure 3: Settlement vs. depth at the left ($x/a = -1$) and right ($x/a = +1$) edges of the loaded area. The infinite element solution closely follows the reference solution throughout the depth.

1.6 Quantitative Comparison

Final results at the center of the loaded area:

Model	Settlement at center (mm)	Error vs. Reference
Small + Infinite	-142.1	+1.5%
Small Truncated	-87.0	-37.9%
Medium Truncated	-113.3	-19.1%
Large Truncated (reference)	-140.0	—

Key finding: With strip topology and `@@RayLength: 4.5` (~2.25× the 2 m domain size), the small domain + infinite elements matches the 8×8 m reference within ~1–2% in center settlement, while the fixed-truncation small/medium domains under-estimate settlement due to boundary stiffness.

1.7 Runtime Comparison

Total analysis time reported by the solver (`run.log`) for the same 10-step static run (load-scaled case used in this example):

Model	Total analysis time (s)	Relative to Large Truncated
Small + Infinite	1.13	11.7× faster
Small Truncated	1.01	13.1× faster

Model	Total analysis time (s)	Relative to Large Truncated
Medium Truncated	4.33	3.1× faster
Large Truncated (reference)	13.23	1.0×

1.8 Ray Length Sensitivity

The `@@RayLength` parameter significantly affects the stiffness of the infinite region in static problems:

- **Shorter rays** → stiffer infinite region → less settlement
- **Longer rays** → softer infinite region → more settlement

For this problem, `@@RayLength: 4.5` (approximately 2.25× the domain width) provides a good match to the reference large domain solution.

Figure: Settlement profile beneath the load center for multiple `@@RayLength` values (small domain with infinite elements), shown alongside the large truncated reference solution. The curves illustrate the stiffness trend with ray length and the calibration point used in this example (`@@RayLength: 4.5`).

Recommendation: For static uncoupled analyses, test ray lengths in the range of 1–5× the characteristic domain dimension and select the value that best matches a reference (larger domain) solution.

1.9 Key Observations

1. **Infinite elements effectively extend the domain** — A small 2×2 m domain with infinite elements produces displacement fields comparable to an 8×8 m truncated domain while using ~15× fewer nodes.
2. **Truncated domains underestimate settlement** — Without infinite elements, fixed boundaries artificially constrain deformation. A 4×4 m domain still shows 19% error; even this 4× larger mesh cannot match the infinite element solution.
3. **Strip topology is appropriate for straight boundaries** — The `@@Topology: Strip` setting generates QUAD8 infinite elements with parallel rays, suitable for representing a semi-infinite half-space.
4. **Ray length requires tuning** — Unlike wave absorption (PML), static infinite elements are sensitive to the ray length parameter. The optimal value depends on the problem geometry and loading.
5. **Infinity boundary conditions** — Avoid fixing both `DisX` and `DisY` at the far boundary for strip topology (it over-stiffens the far field). If `@@DisX/@@DisY` are omitted, the default behavior is a roller-style constraint (normal component only).

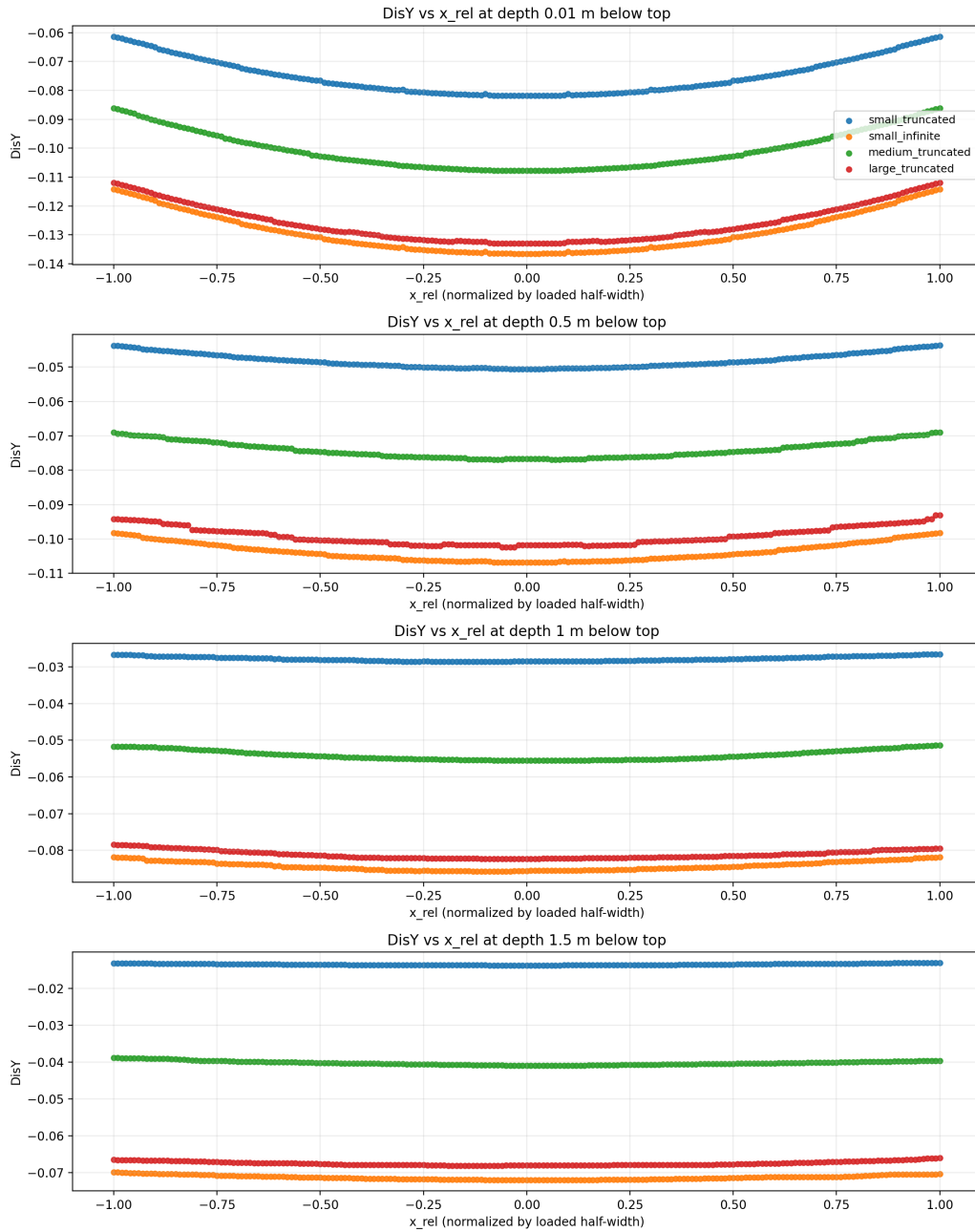


Figure 3: Figure 2: Displacement at various depths

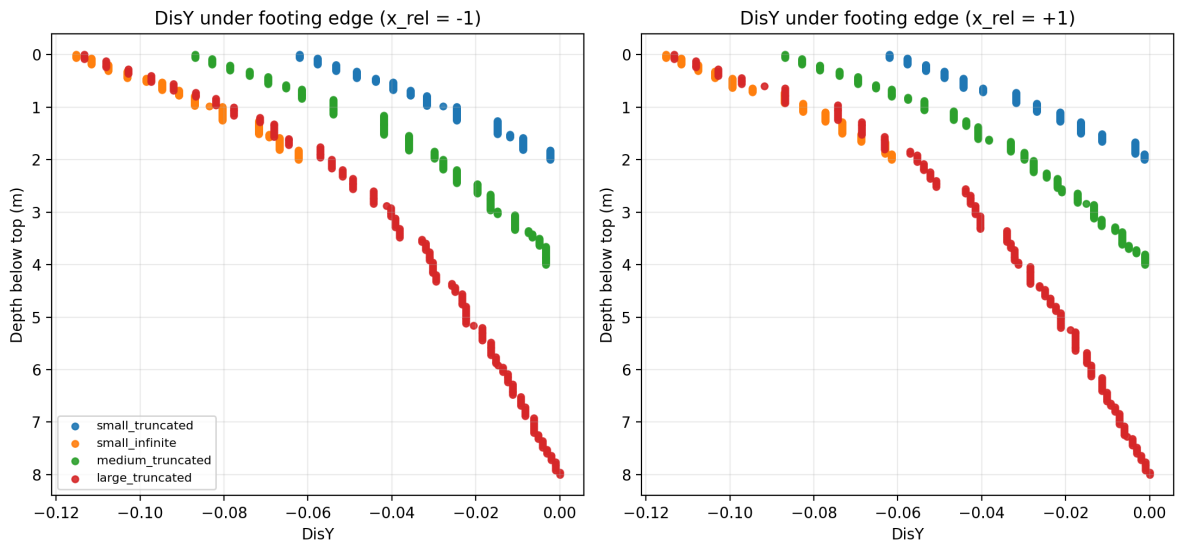


Figure 4: Figure 3: Settlement at footing edges

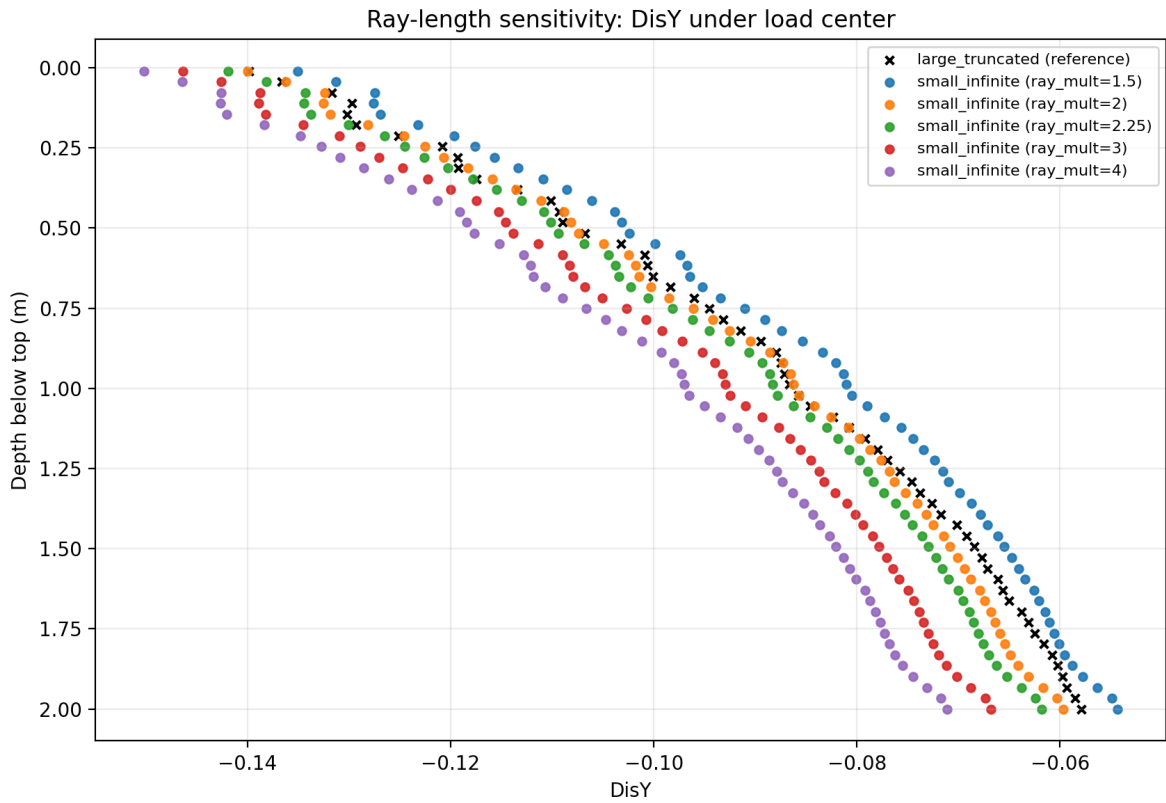


Figure 5: Ray-length sensitivity: settlement beneath load center

1.10 Comparison with Other Boundary Treatments

For **static** analyses where far-field representation is needed:

- **Infinite elements** — Geometric mapping extends the domain to infinity; good for static problems with proper ray length tuning
- **Larger truncated domain** — Simple but computationally expensive
- **Fixed boundaries** — May introduce spurious constraints near boundaries

For **dynamic** analyses:

- Use **PML (Perfectly Matched Layer)** for wave absorption
- Infinite elements do not absorb waves and may cause reflections

See also: [Infinite Elements](#), [PML](#), [Sponge Layer](#)

