Future Infrastructure Forum

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1. Large scale computations

Continuing to use advancing capabilities to study problems in new ways – improve remaining approximations

- Bridge-foundation-water interactions (e.g. during seismic events)
- Wind-structure interactions
- Simulating construction and its effects

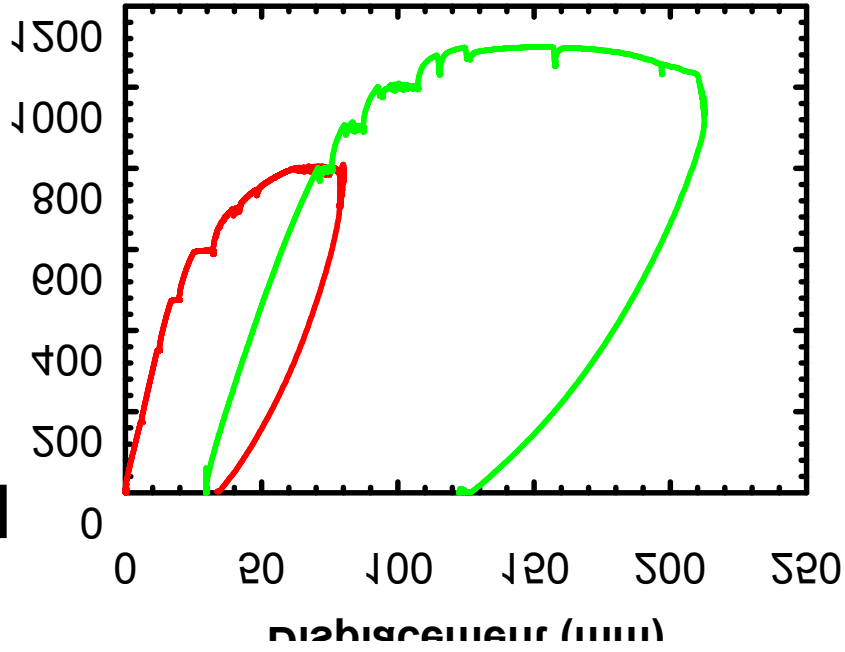
1. Large scale computations

Example - understand culvert strength limit states & influence of 3D effects – Testing (Lougheed) and Analysis (Elshimi)

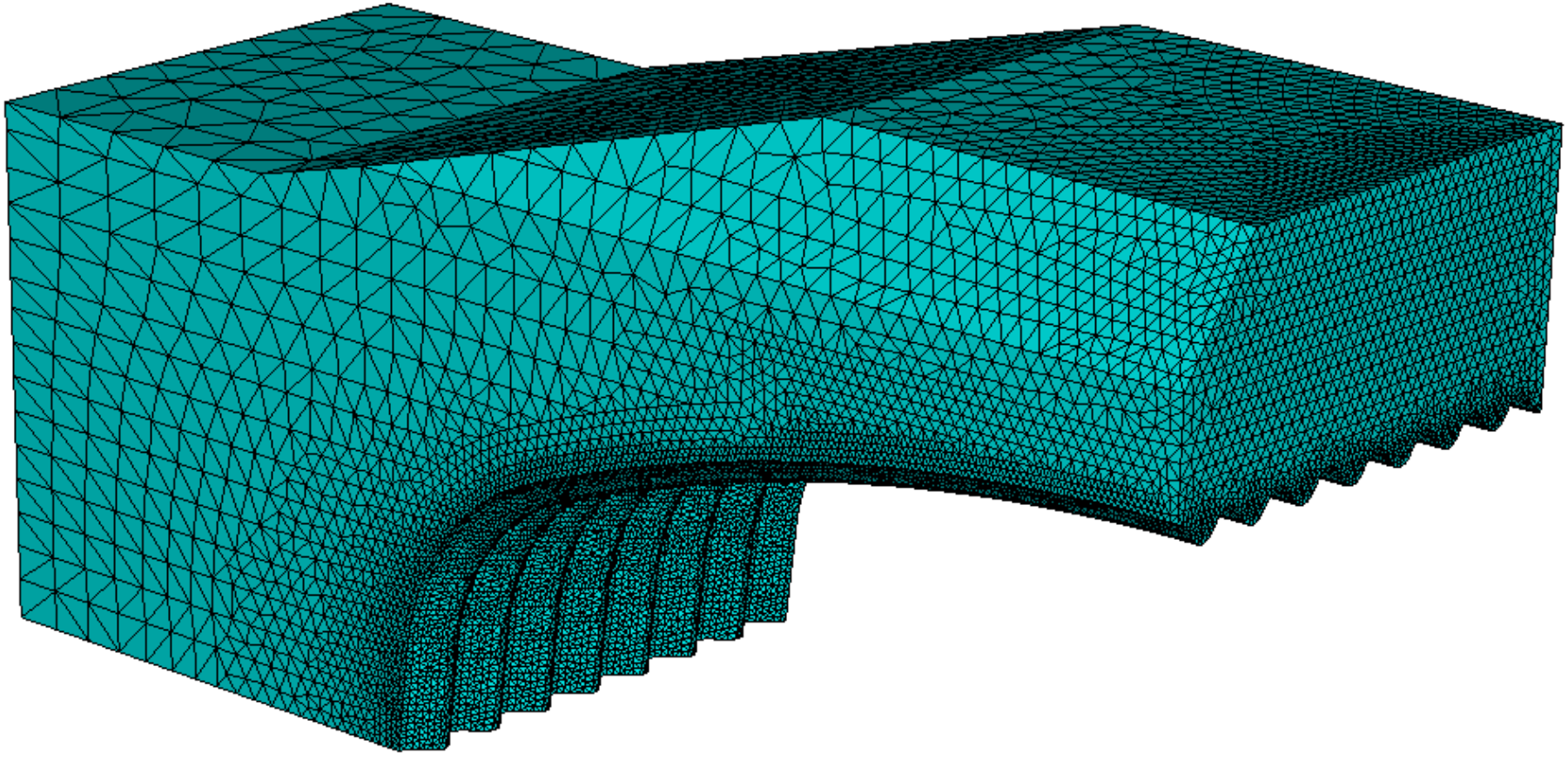
Ultimate Limit State Tests

Two ultimate limit states

- Standard load pad
  600 x 250 mm – CHBDC
  (AASHTO) wheel : 800 kN
  Bearing failure of soil
- 2.5 times larger pad
  950 x 390 mm : 1100 kN
  Plastic moment capacity
- CHBDC: 597 kN required
  / resistance factor = 630kN
  = 1100kN / 1.7

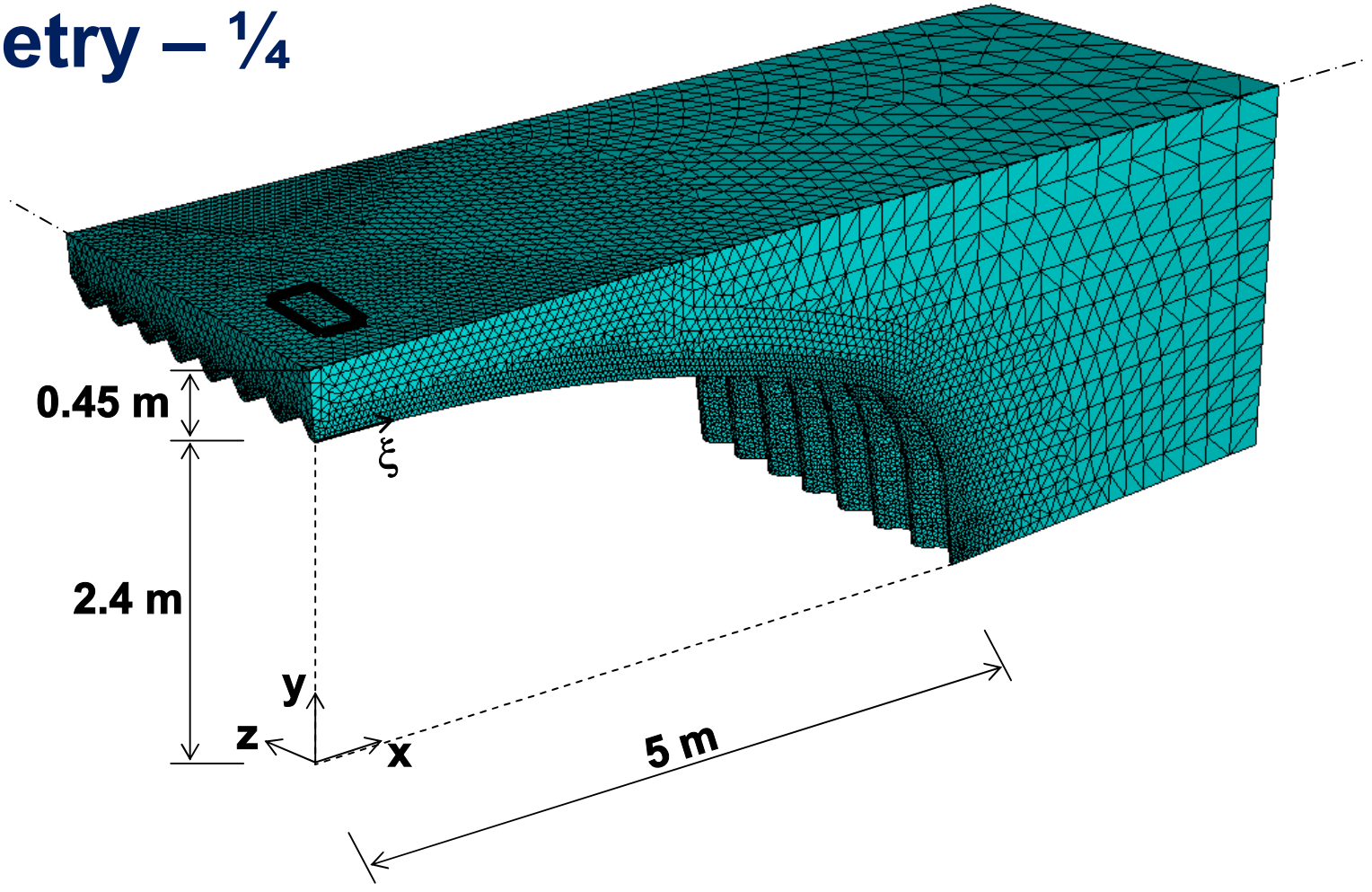


Three dimensional behaviour: analysis and design
Tamer Elshimi (PhD, 2011)

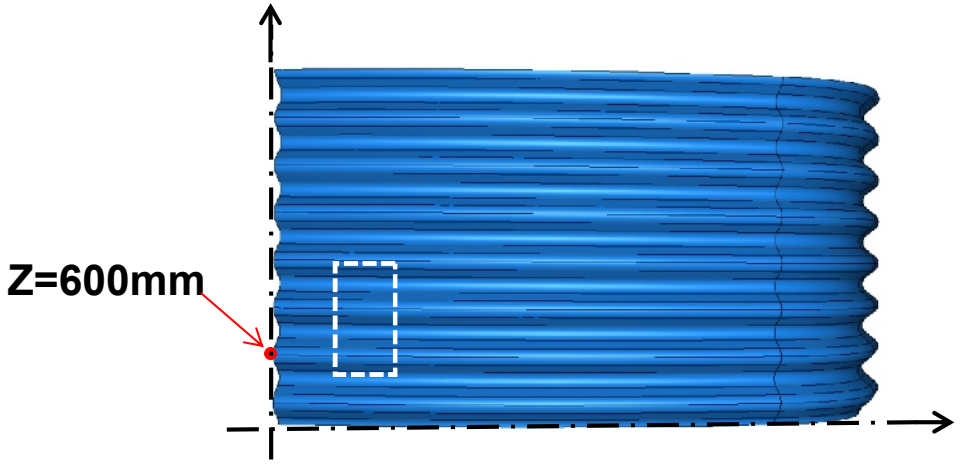


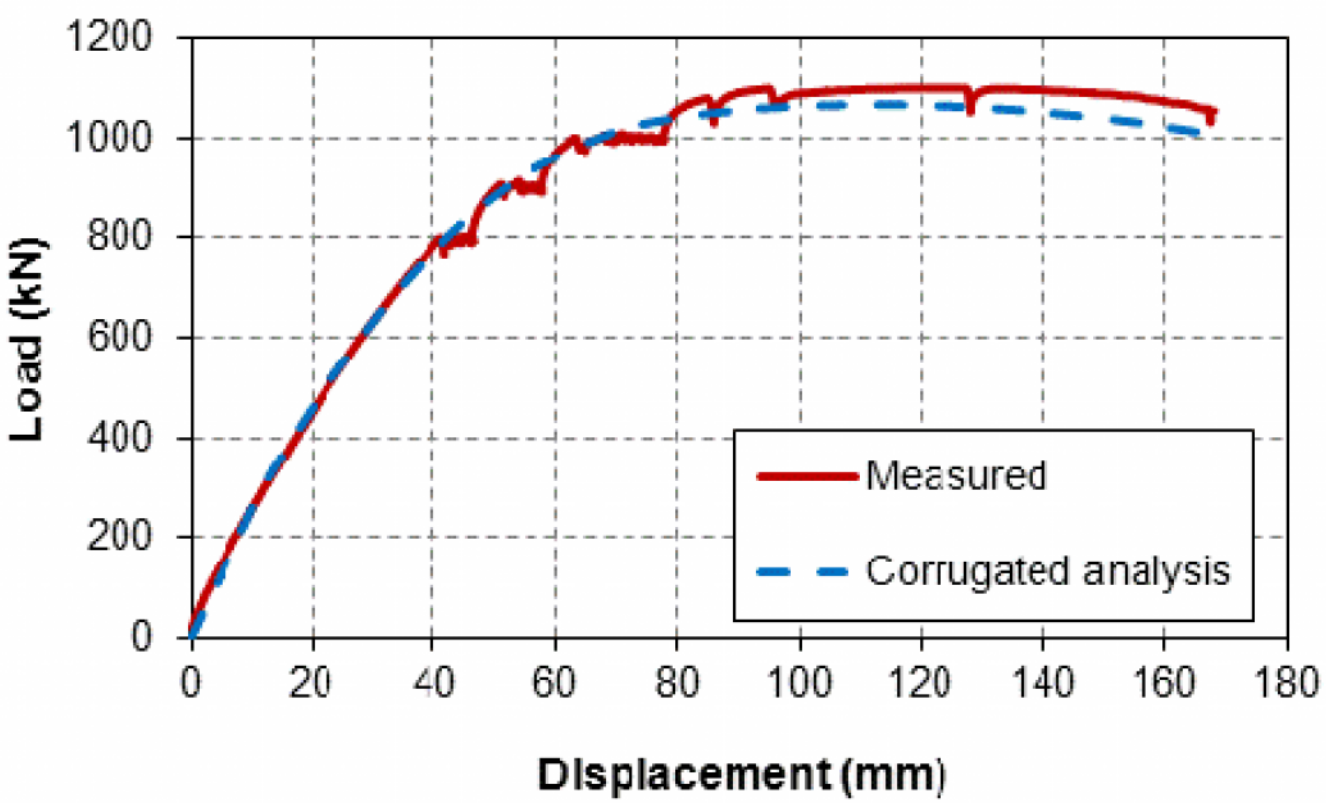
ABAQUS analysis

Geometry – ¼

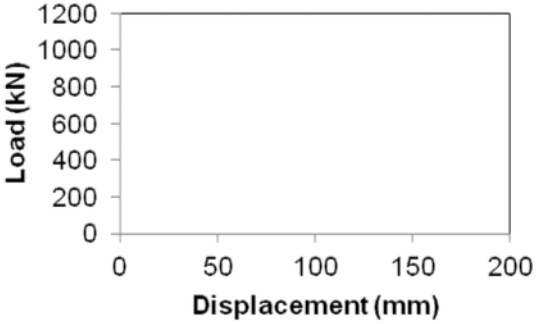


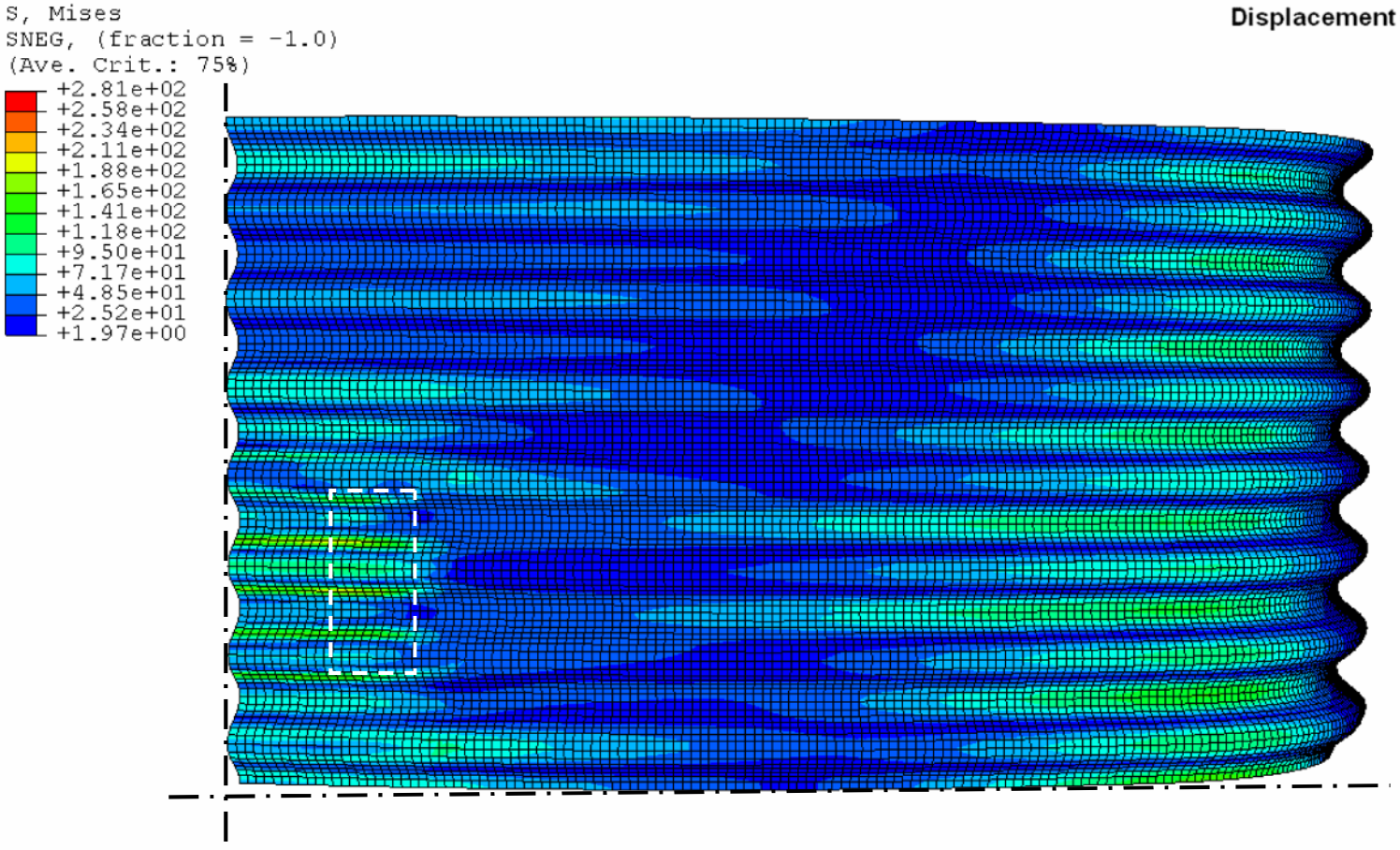
Loads and deformations





Yielded zones





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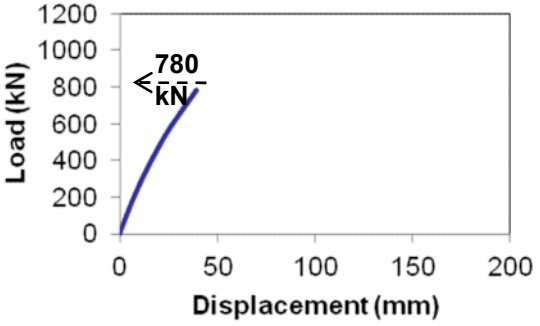

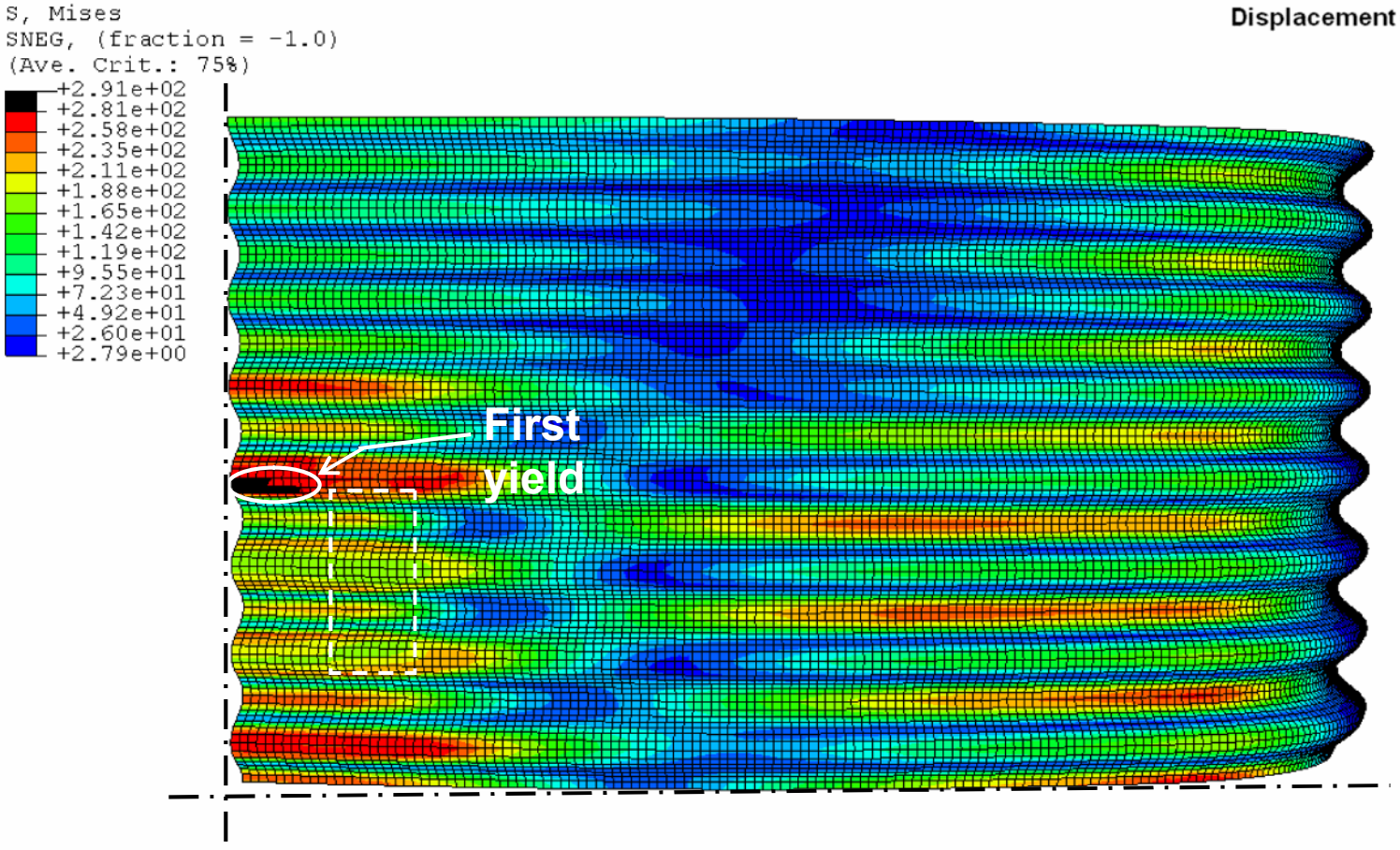

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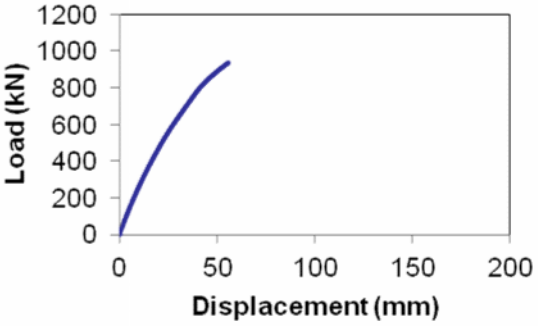

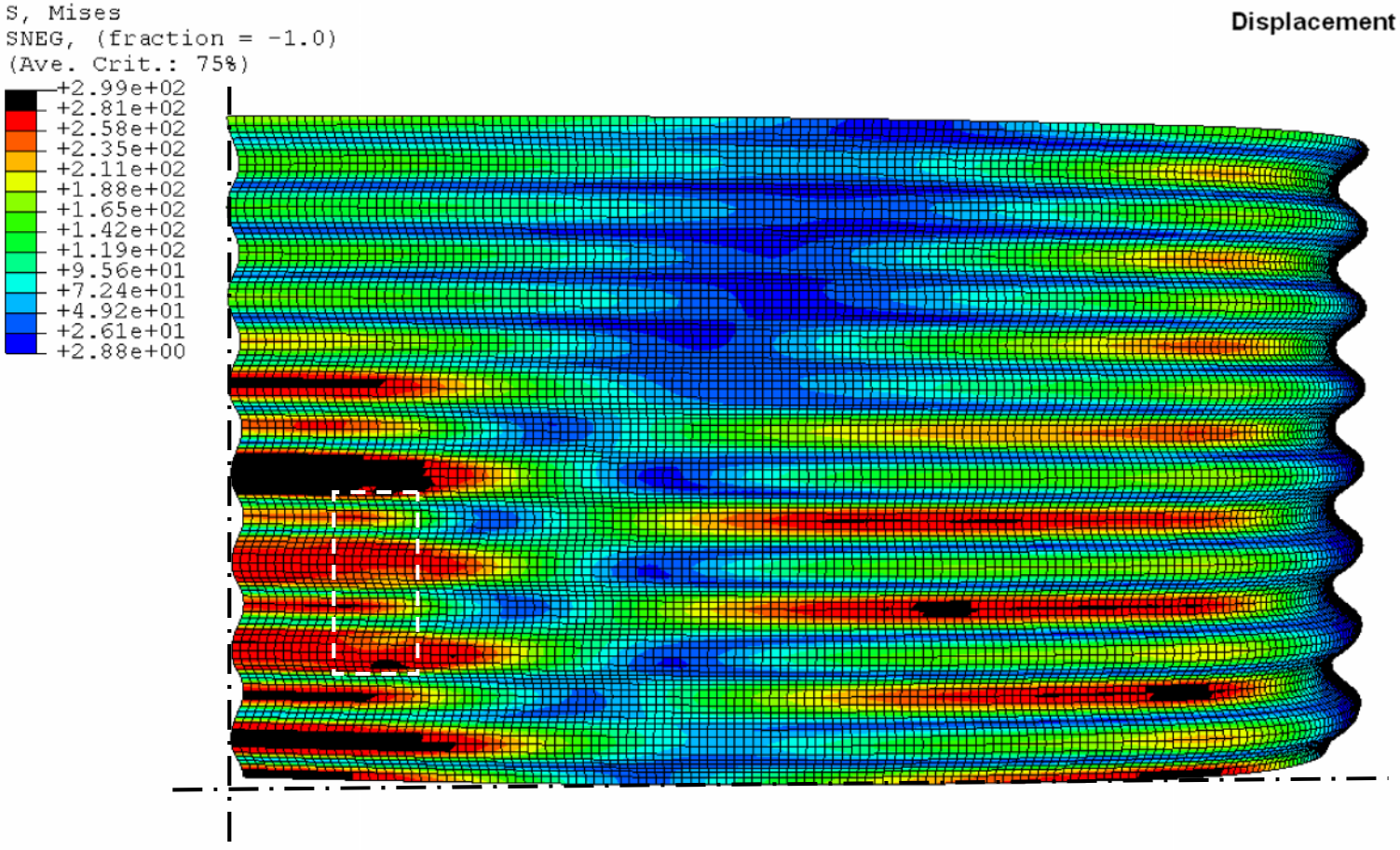

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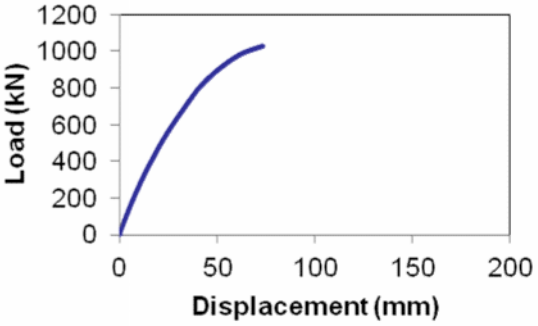

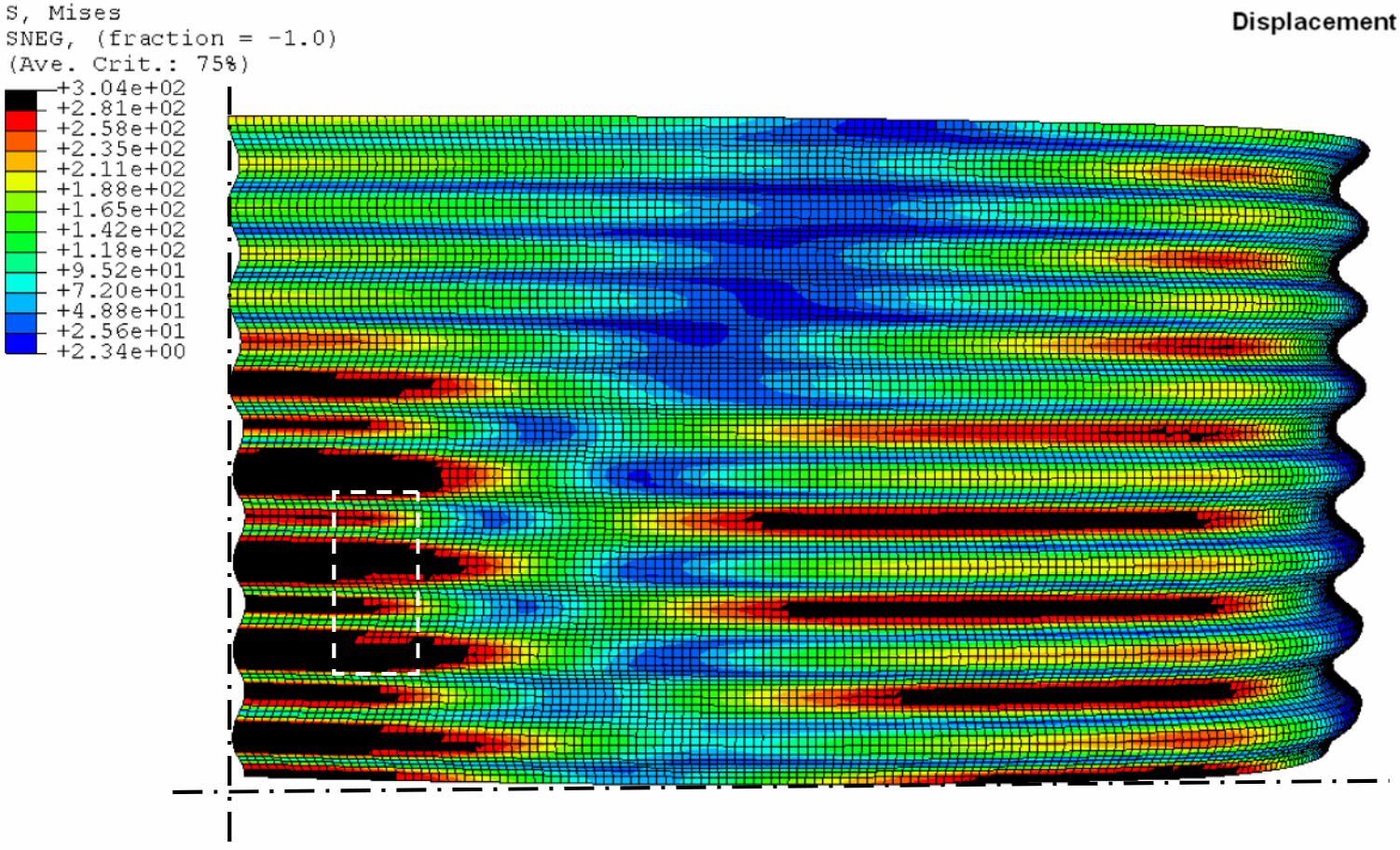

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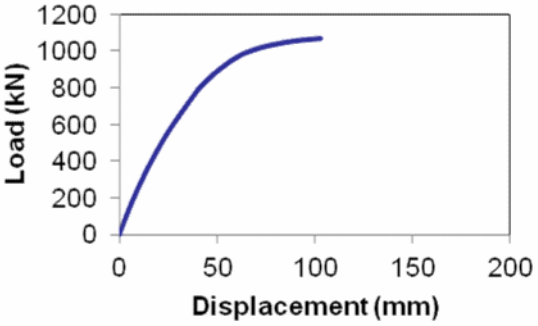

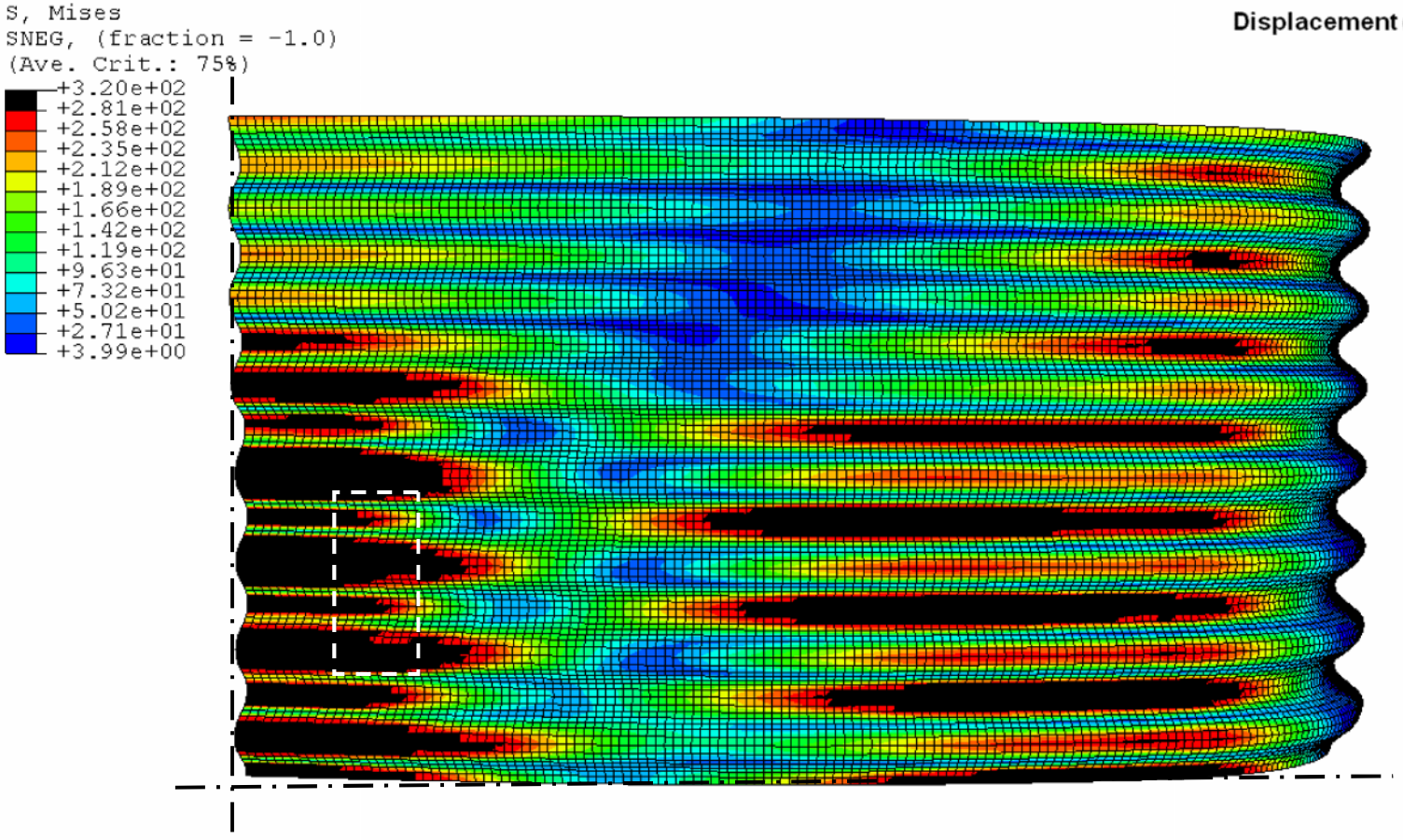

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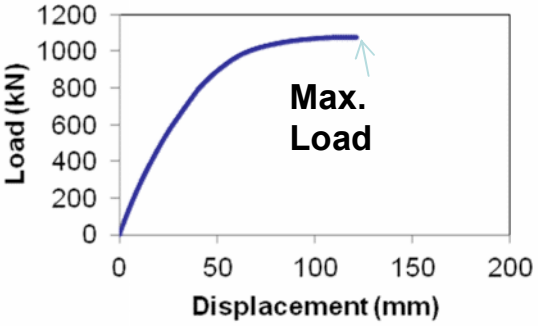

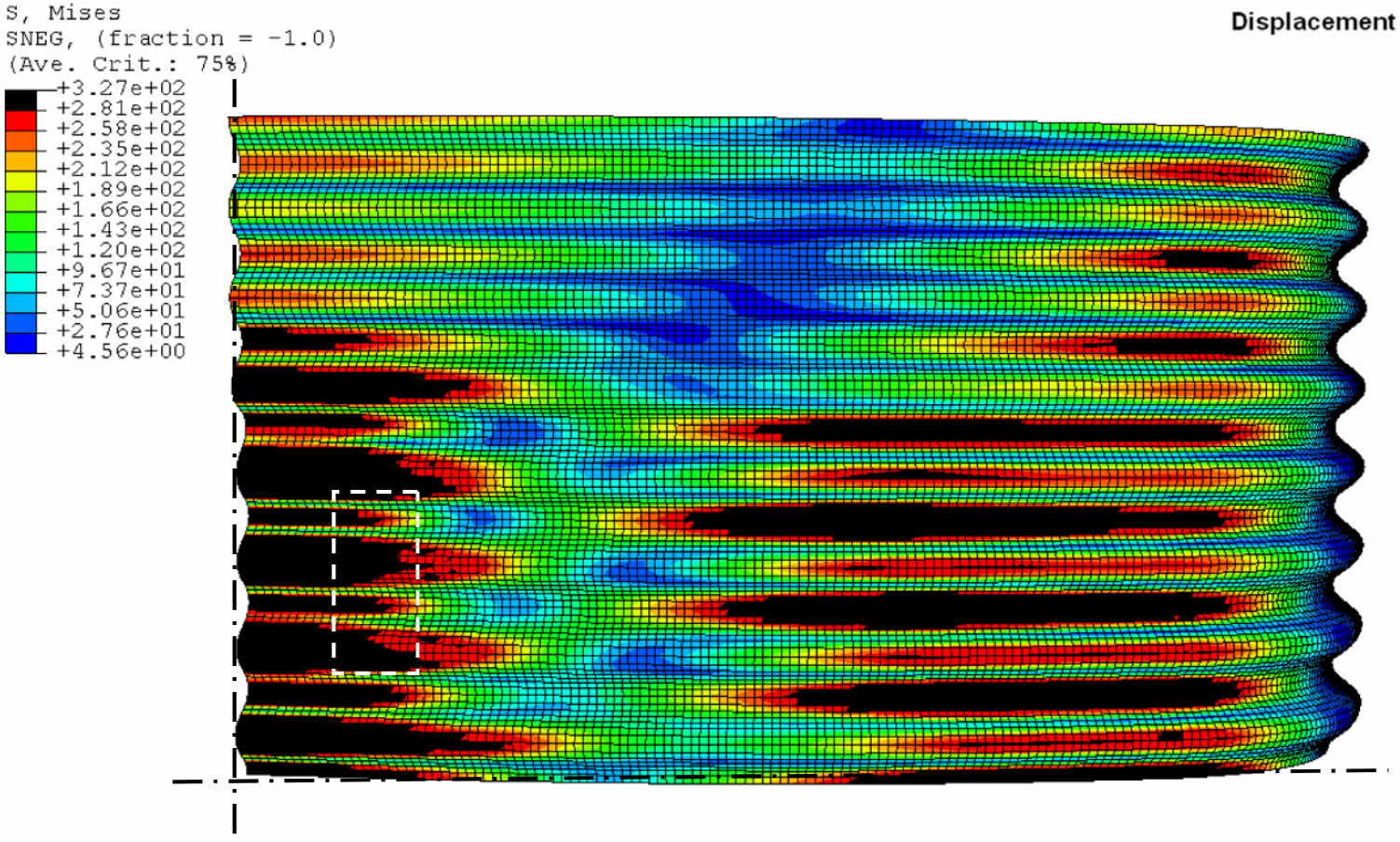

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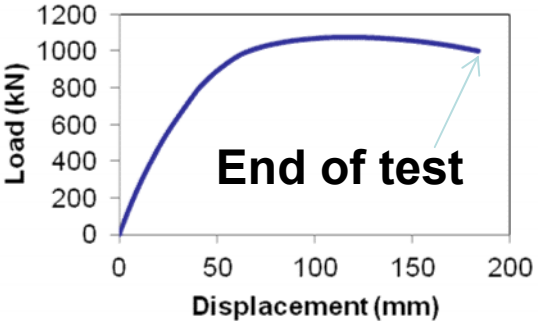
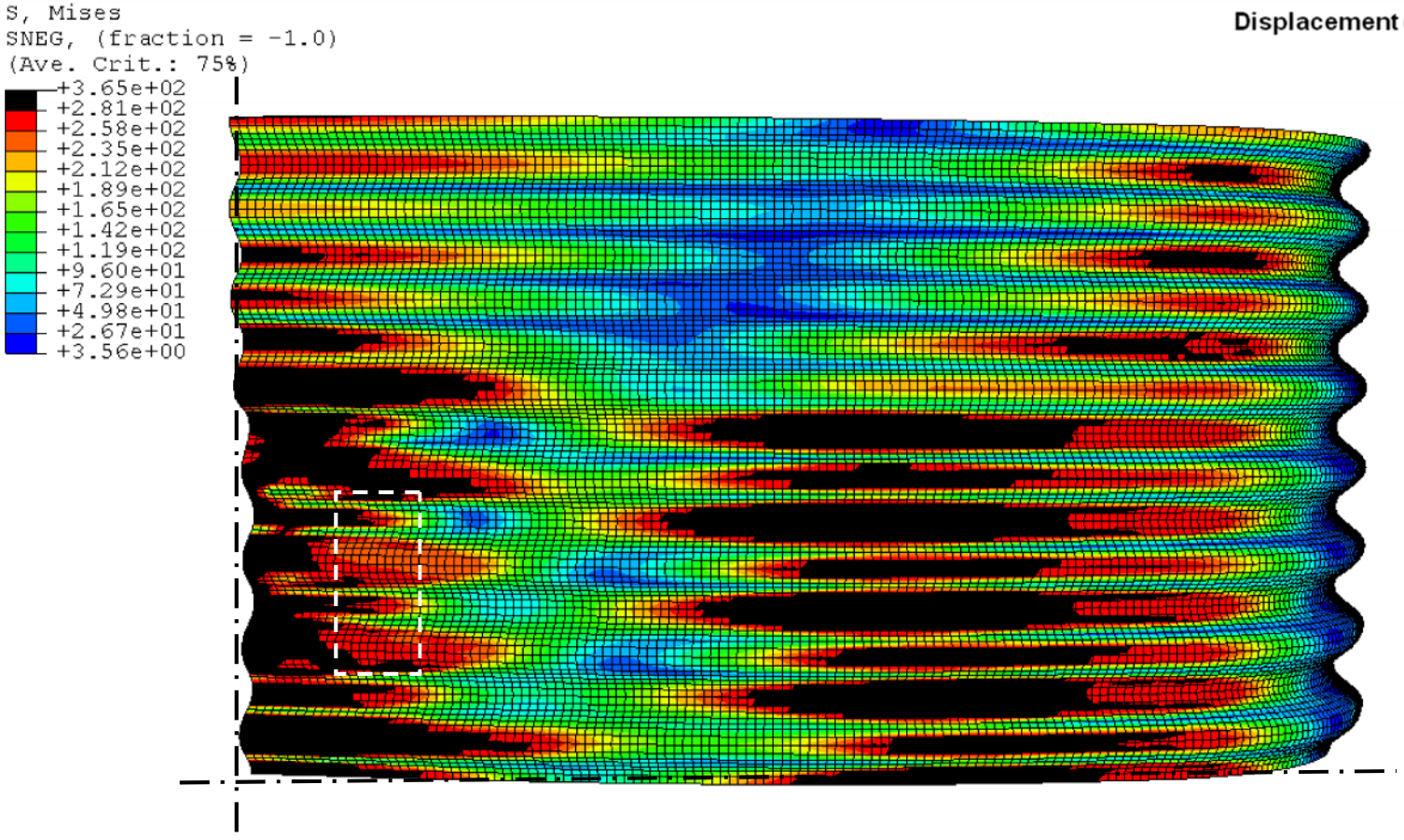
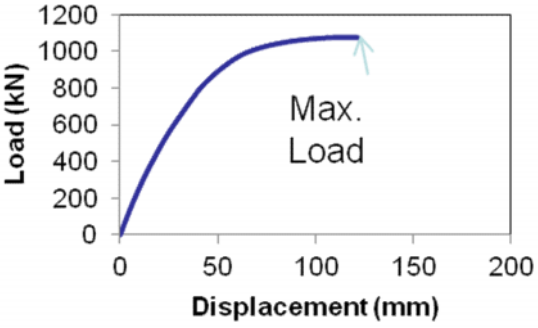
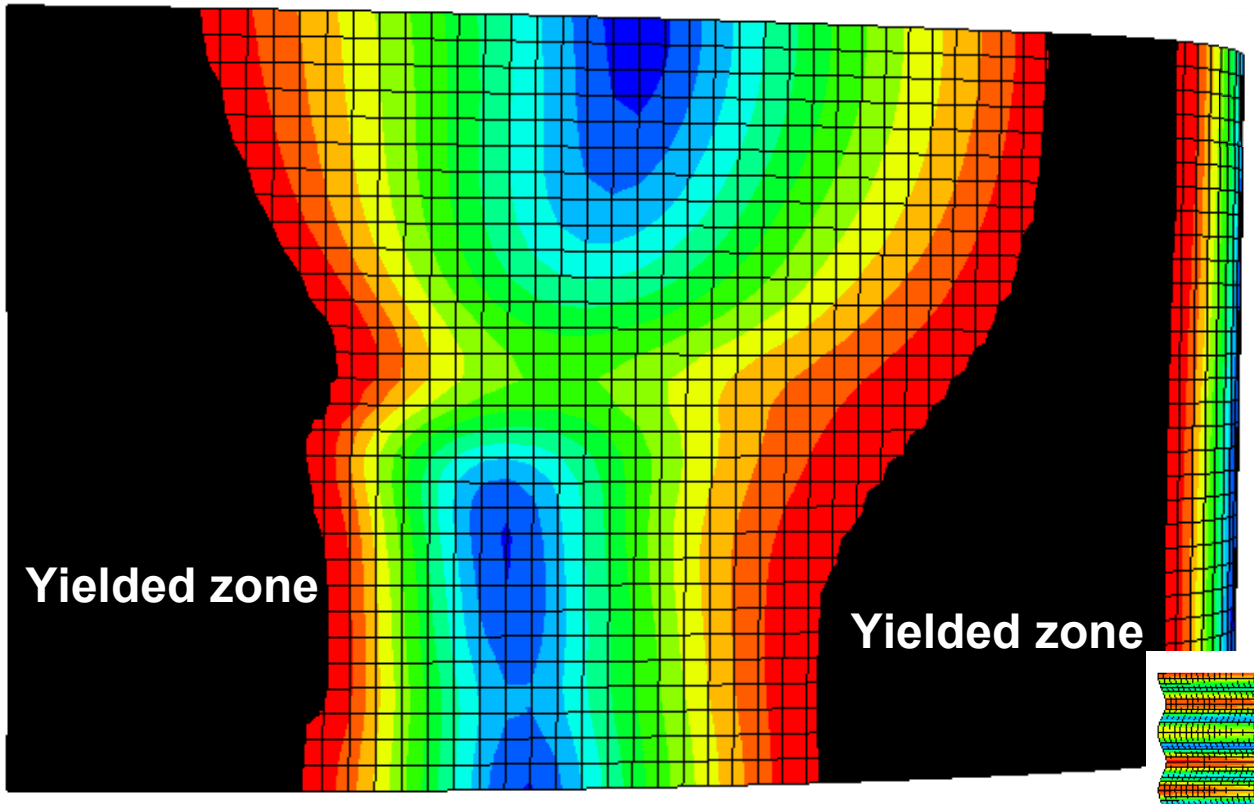
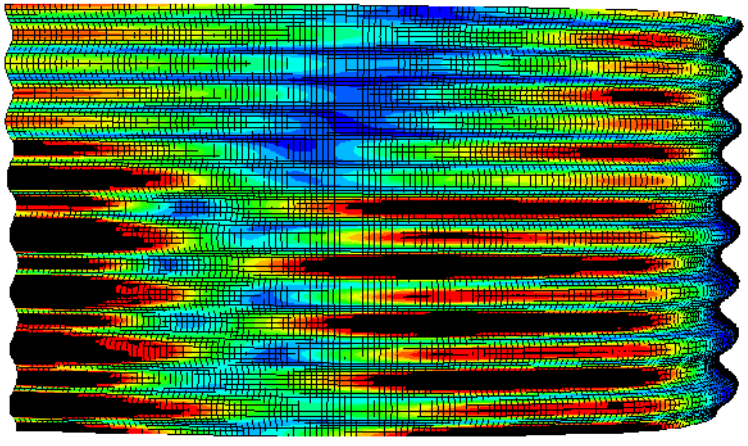




Orthotropic shell performance

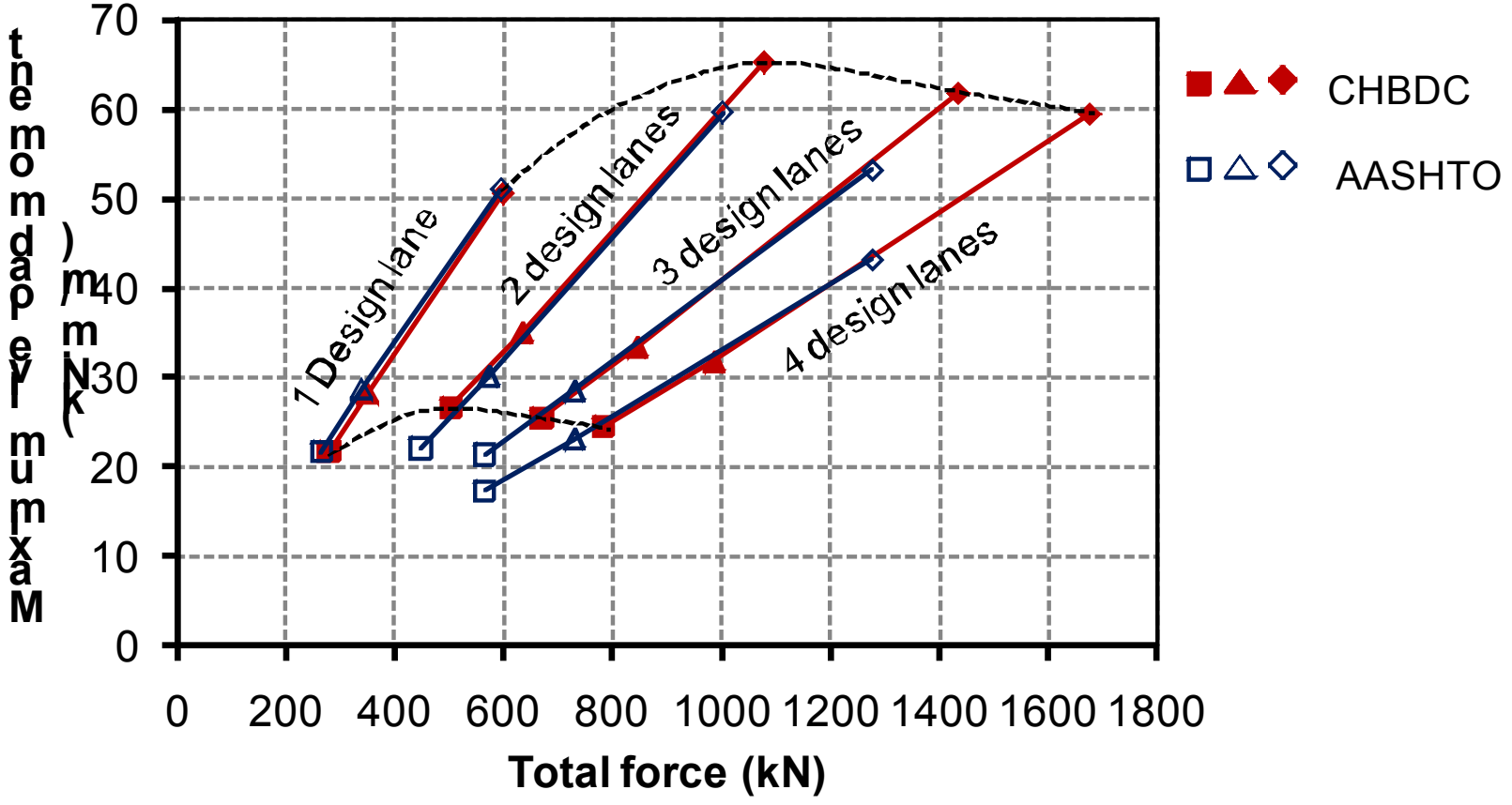






Top surface (represents crests only)

Load choice for parametric study



■ □ P1 = Multiple presence factor (MPF) x Nominal load

▲ △ P2 = Dynamic load factor (DLF) x P1

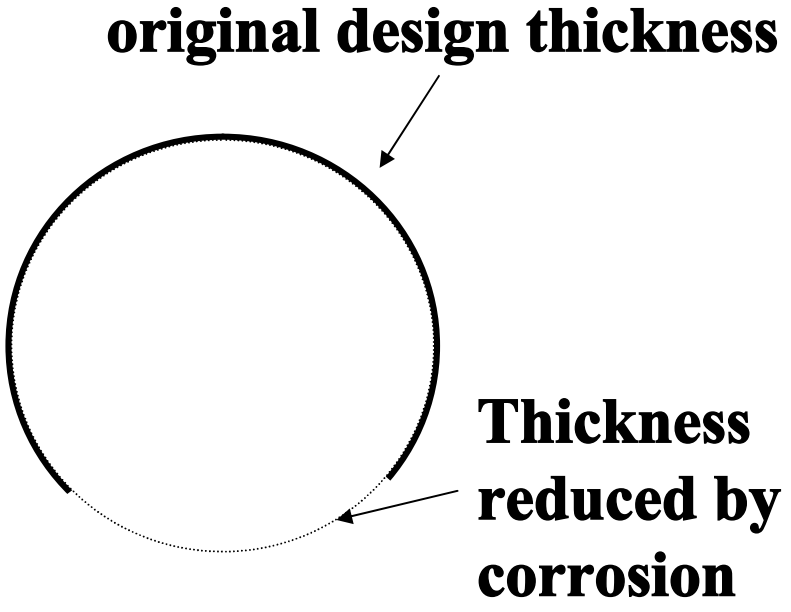
◆ ◇ P3 = Live load factor ($\square_L$) x P2

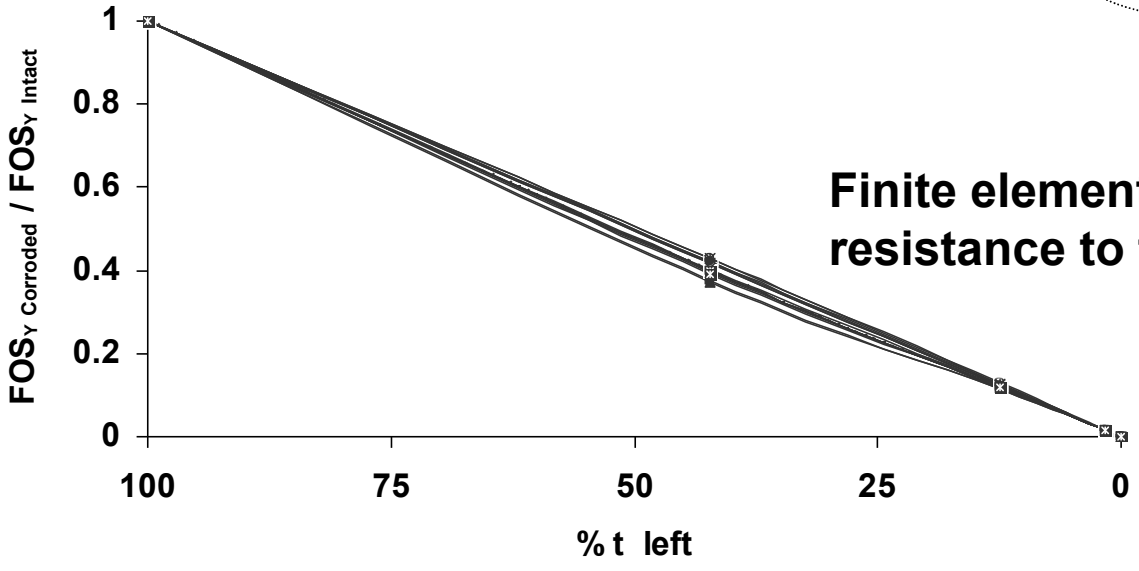
2. Infrastructure deterioration

- > 80% of Civil Eng. construction – repair or replacement; need to determine: "how much deterioration is too much?"
- including deteriorated soil (erosion)

Metal culvert, Hwy 401, ON

Invert corrosion

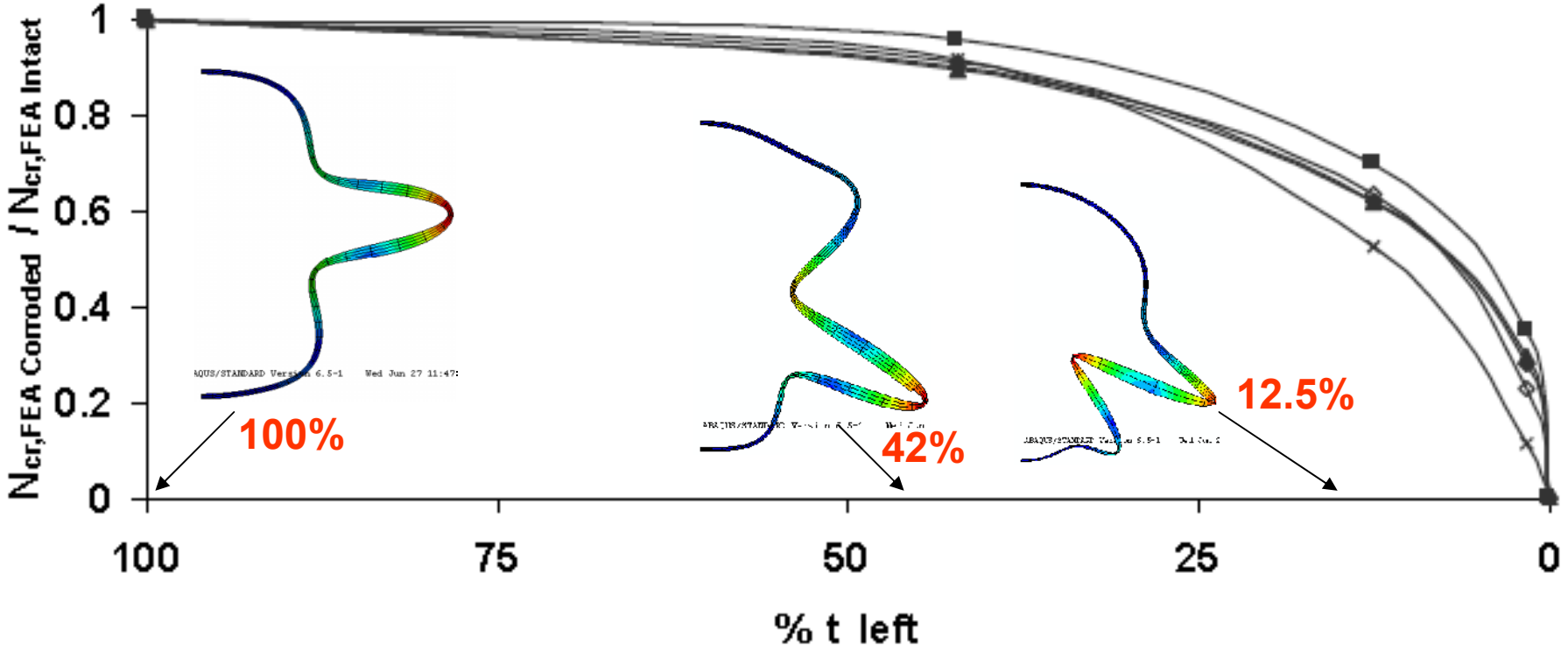




Finite element analysis to determine resistance to failure by wall crushing.

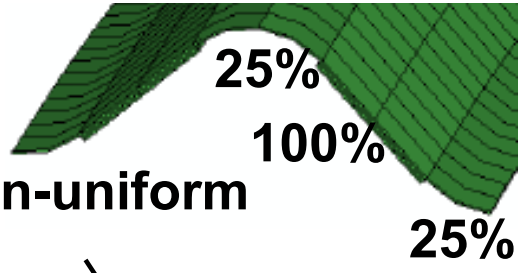
Global buckling strength

Reductions in stability are slow until significant wall loss has occurred (corrosion across angle of 135º)

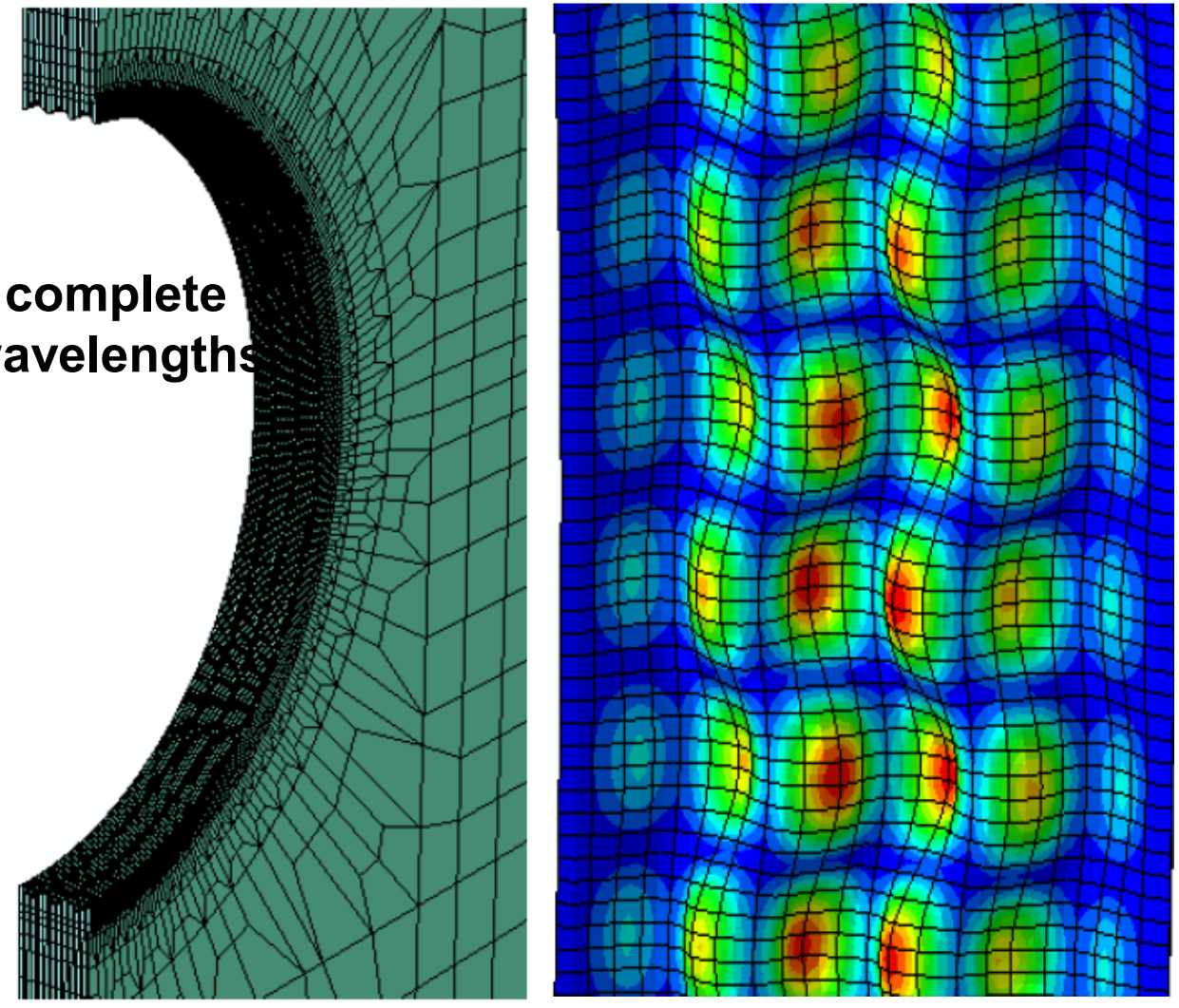


Non-uniform versus uniform corrosion

Non-uniform - 25% remaining at the crest and valley, intact elsewhere (62% of the area remains).



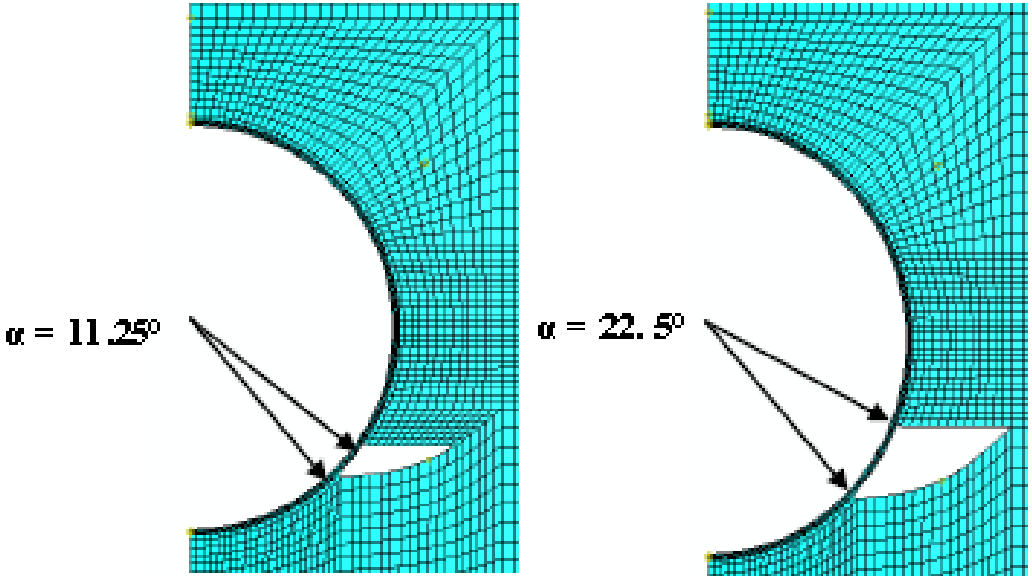
Local buckling

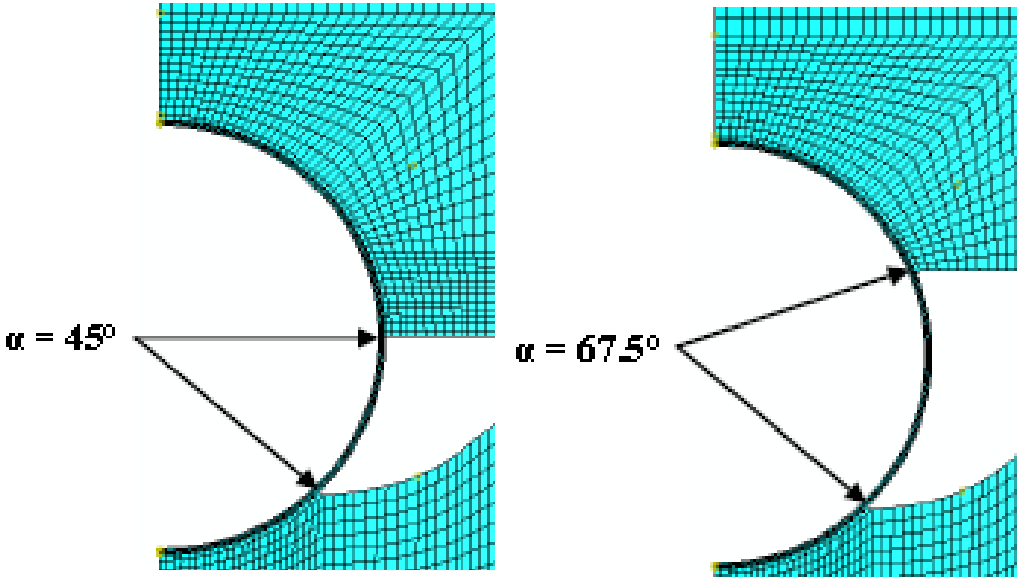


Solution for
3 mm plate

Local rather
than global
buckling
governs when
wall thickness
is less than
4 mm.

Influence of backfill erosion

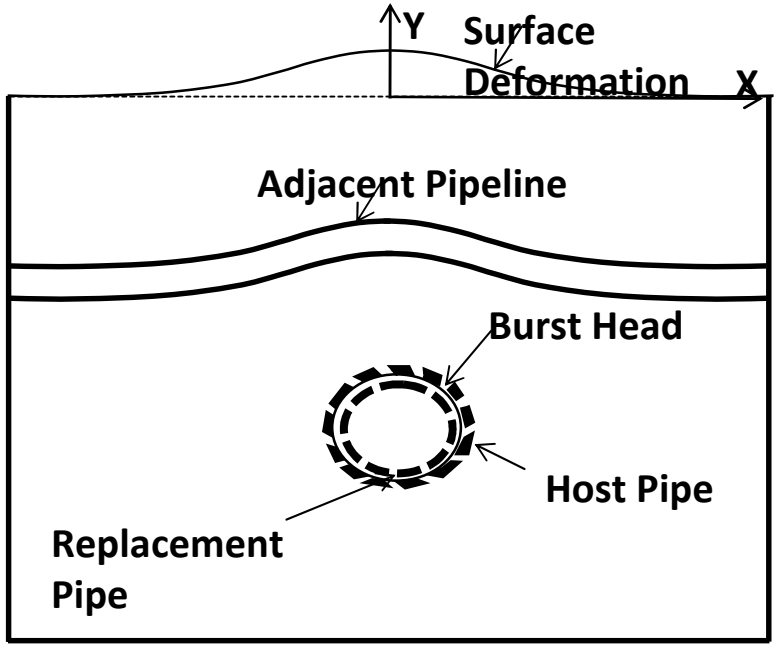




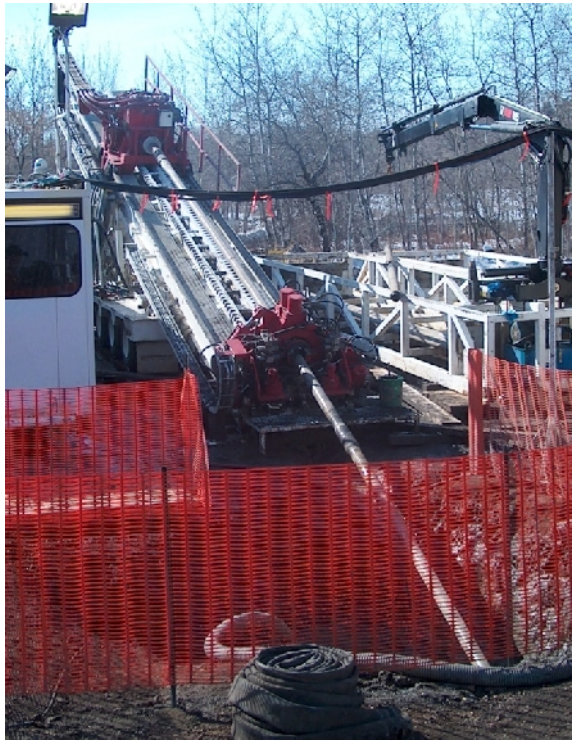
3. Infrastructure rehabilitation

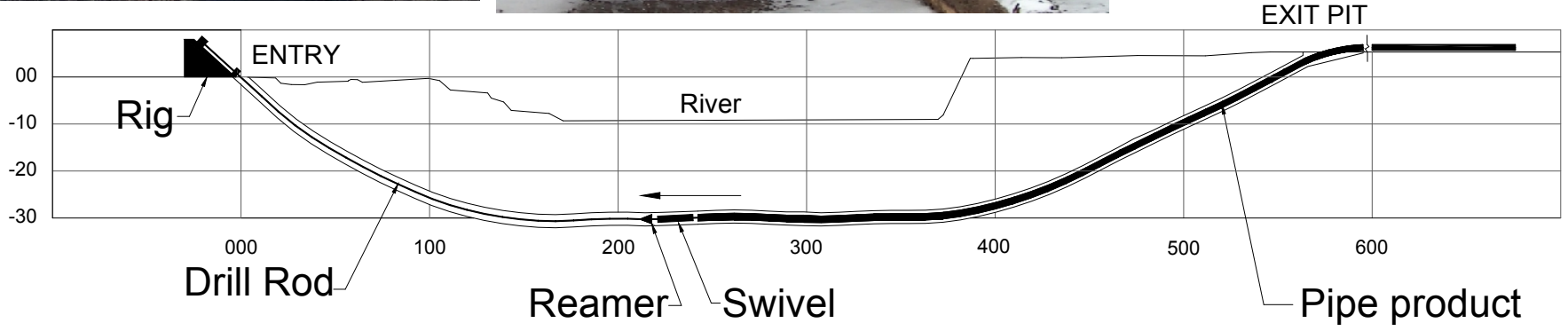
Culvert lining, East ON

Sewer replacement, Ottawa

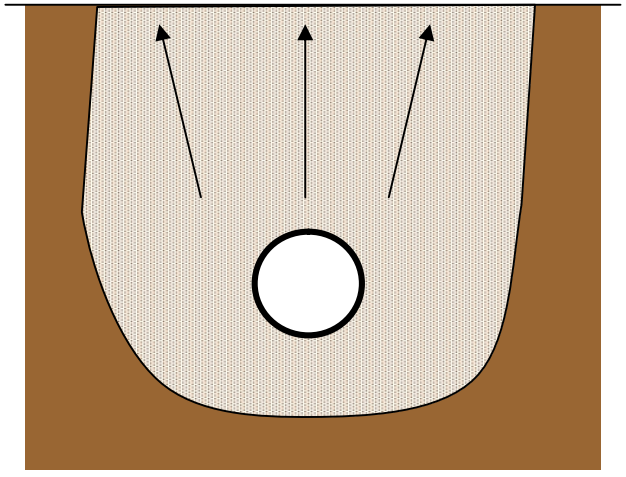


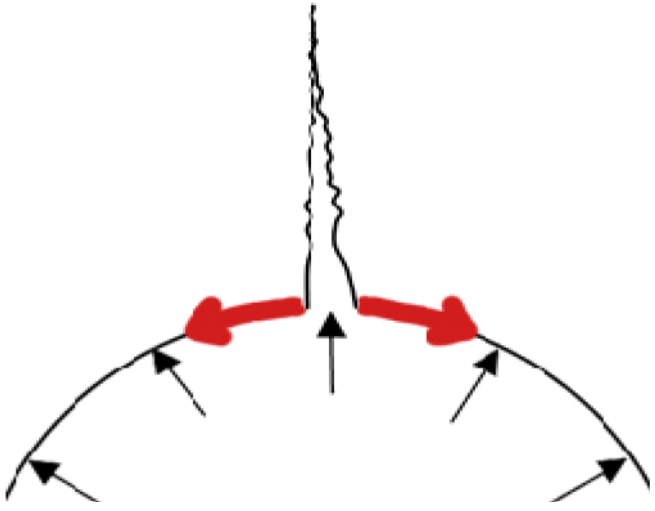
4. Poor/sensitive soil environments

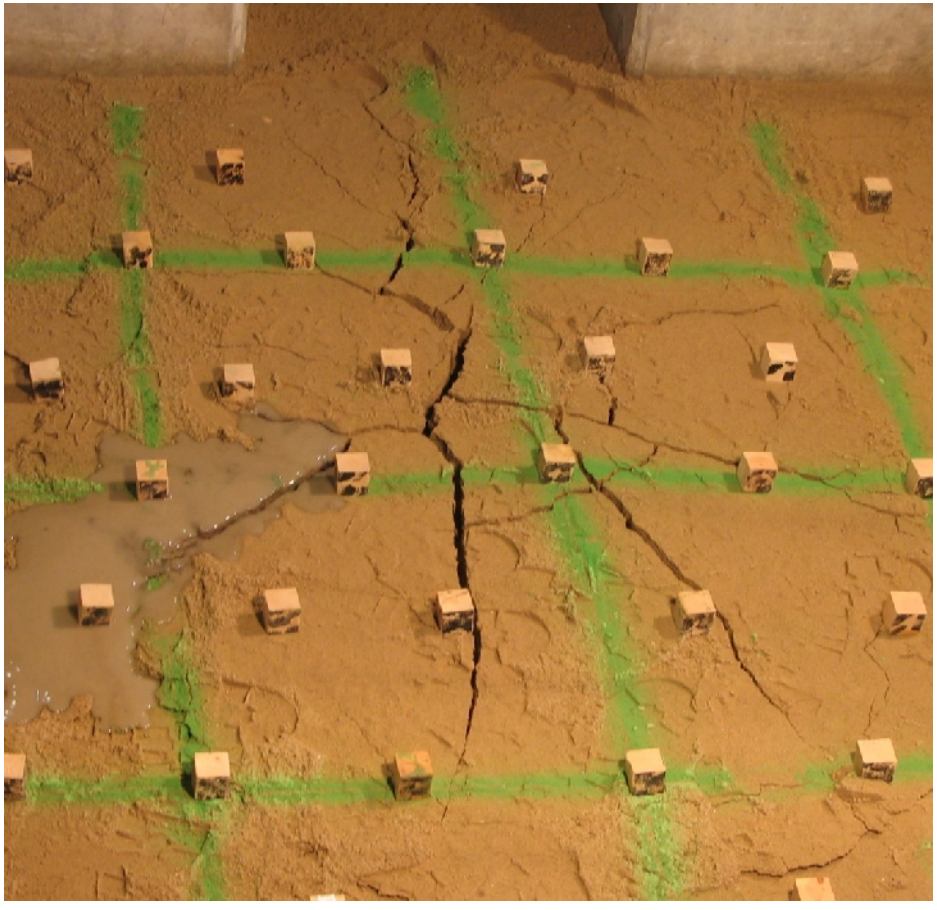




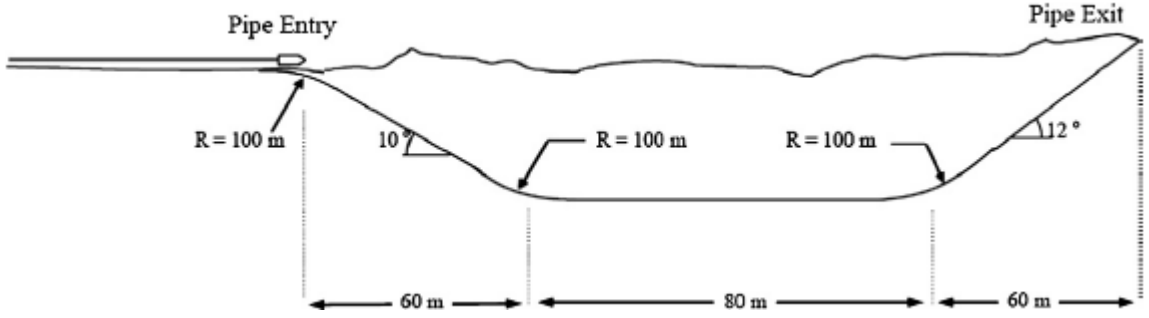
Mud-loss during directional drilling

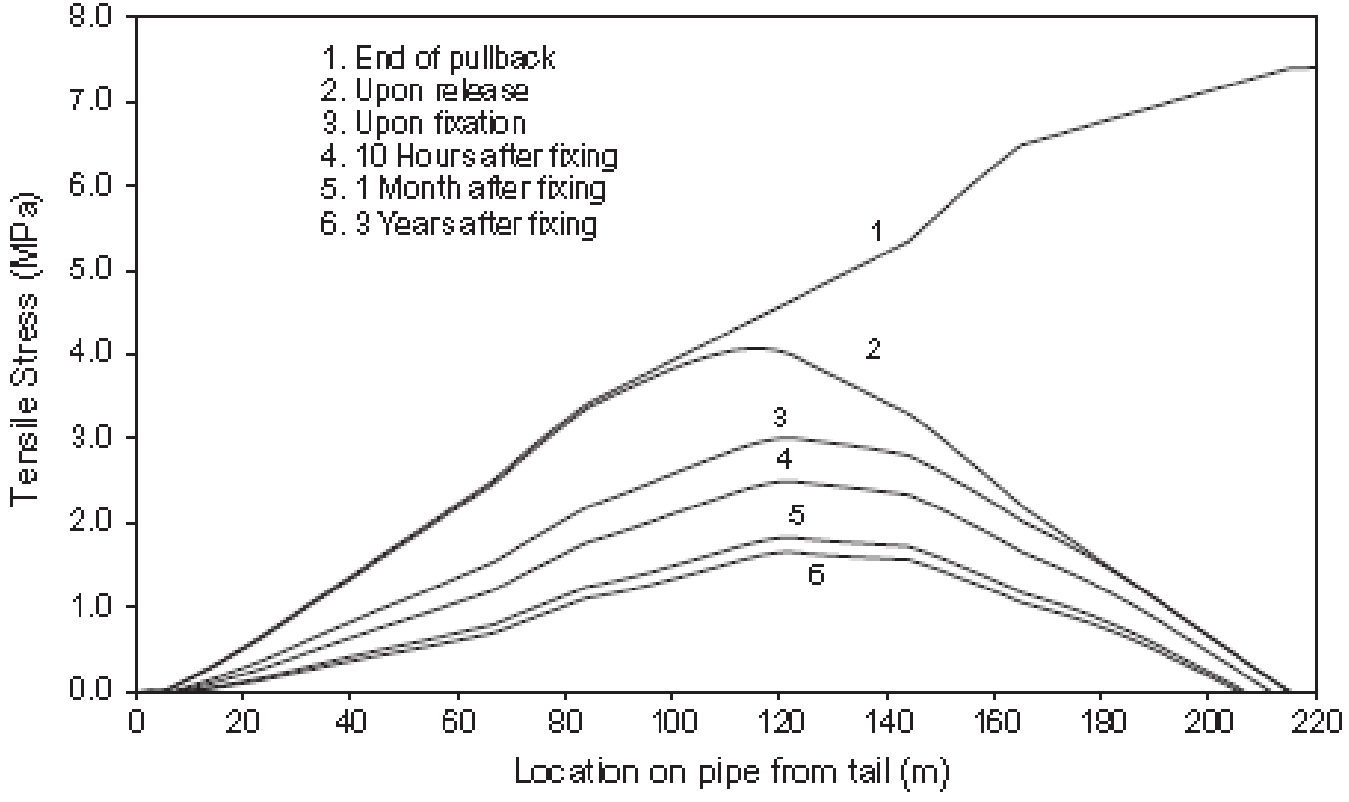






5. Construction and service life

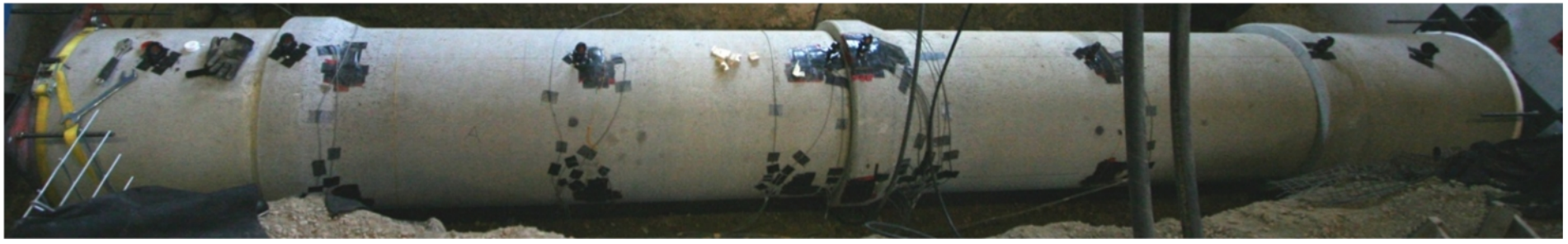




Simulate pipe installation by directional drilling; then determine how axial forces change over the life of the pipeline

6. Improved service lives

For example, buried pipe research focuses on barrel performance, while many failures occur at joints; new work has developed rational design methods for joints



7. Performance-based codes

Stormwater detention chambers
Arches, crates, pipes, ...
HDPE, PVC, PP, Steel, ...
CSA B182 Standards

AASHTO truck
1. short term load factor 1.75
2. one month – load factor 1.0
3. long term – earth loads

- **Define load requirements**
- **Structural testing required**
- **Define tested product**
- ***Test all variations?***
- **Needs sophisticated users (not a single product)**
- ***How to monitor quality?***

Research Themes

1. Large scale computations
2. Infrastructure deterioration
3. Infrastructure rehabilitation
4. Poor/sensitive soil environments
5. Construction effect on service life
6. Improved service lives
7. Performance-based codes

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