

Advanced Pipe Laying

MIP Symposium "Projecten voor 't Voetlicht"



IHC Merwede
Smitweg 6, Kinderdijk

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14 June 2011, 14.00 p.m.

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Heerema Marine Contractors



Delft University of Technology



Dosto Engineering



Kuroki Tubes and Pipes



Maritiem Innovatie Programma

Tendencies in Oil and Gas Industry

- World primary energy consumption increases
 - Oil depletion has become more difficult:
 - More harsh environments
 - More difficult reservoirs
- Significant increase in corrosive products
- Desire for:
- Longevity in the initial completion
 - Lower cost interventions


Advantages Lined Pipe

- Corrosion mitigation methods:
 - Corrosion inhibitors
 - Plastic coating
 - Corrosion allowance
 - Solid Corrosion Resistant Alloy Pipe
 - Double Walled Pipe

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Not feasible when long term corrosion resistance needs to be guaranteed

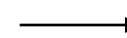
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Expensive

Advantages Lined Pipe

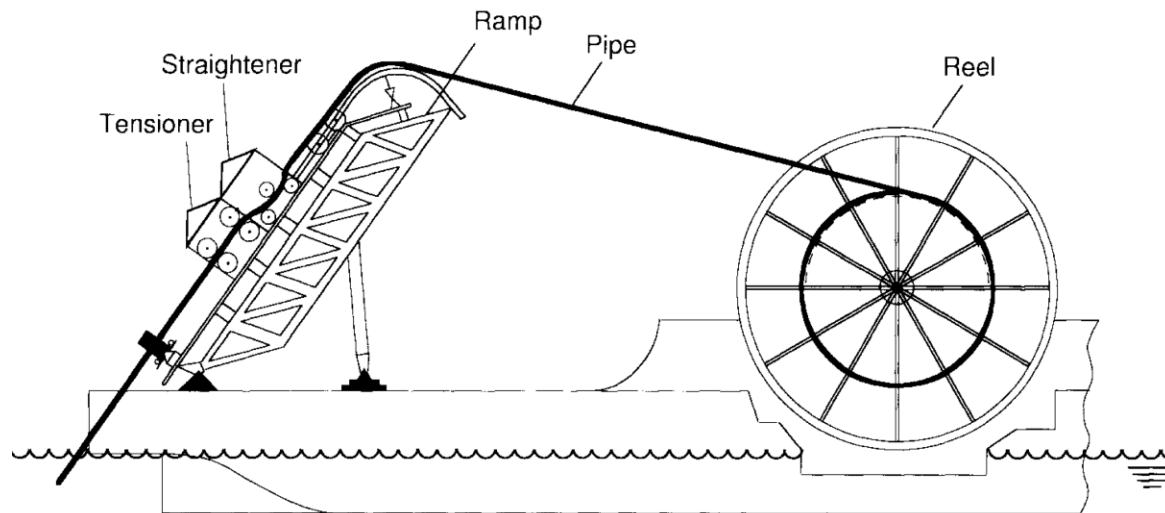
Double walled pipes:

- Types:
 - Metallurgically bonded; Clad pipe
 - Mechanically bonded; Lined pipe
- Advantages lined pipe over clad pipe:
 - Less expensive than clad pipe
 - Shorter lead times

Installing Lined Pipe with Reeling

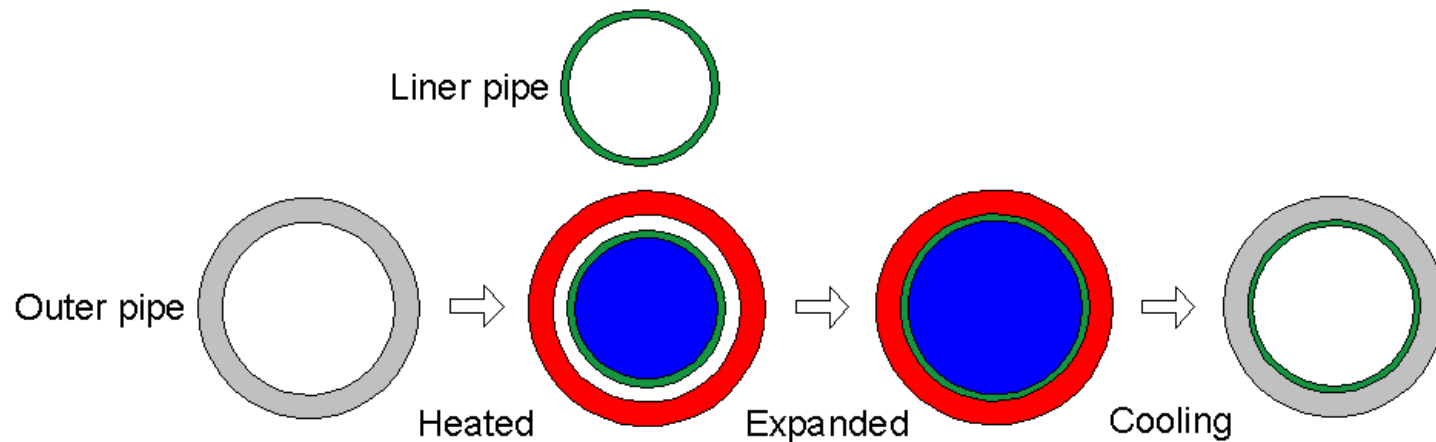
Main advantage:

- Remove difficult clad welds from critical path offshore



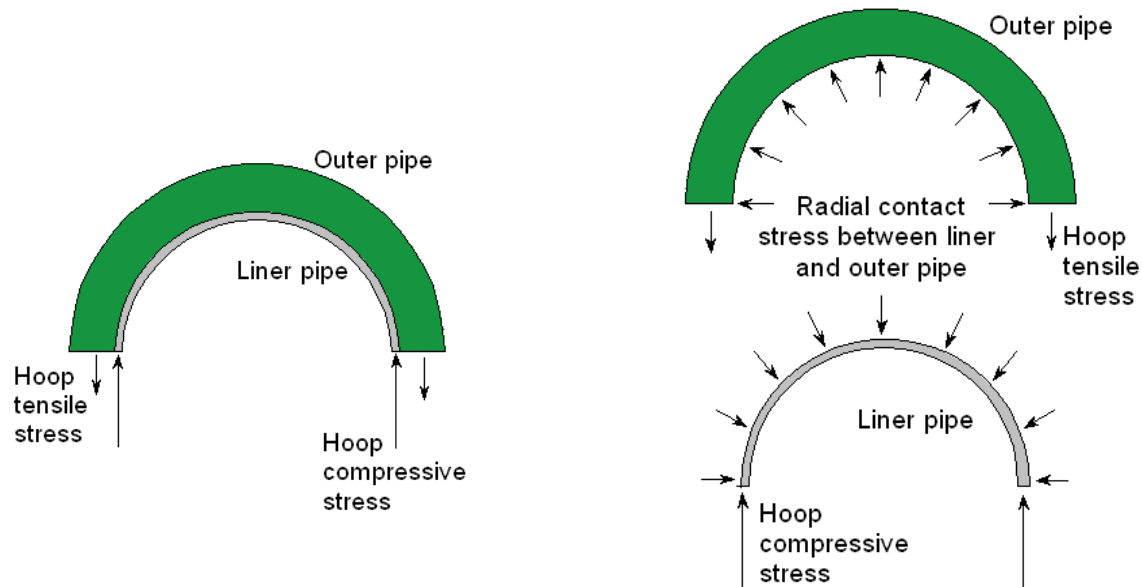
Manufacturing of Lined Pipe

- Kuroki Tight Fit Pipe:
Thermohydraulic expansion of full pipe length



Manufacturing of Lined Pipe

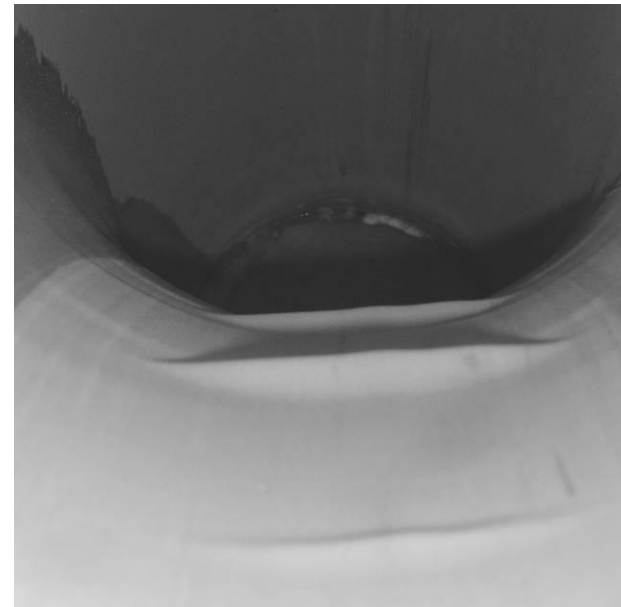
- Resulting mechanical bond



Mechanical Limitation of Lined Pipe

Liner wrinkling

- Onset of liner wrinkling:
 - Occurs during bending of pipe at strains between 0.5 to 2%
 - Related to mechanical bonding
 - Related to ovalisation
- Limitations:
 - Potential fatigue initiation site
 - Reduce the internal cross-sectional area



Research Objective

- Objective:
Identify all variables that do influence the mechanical behaviour of lined pipe during bending, and to determine their influence on this behaviour

Research Objective

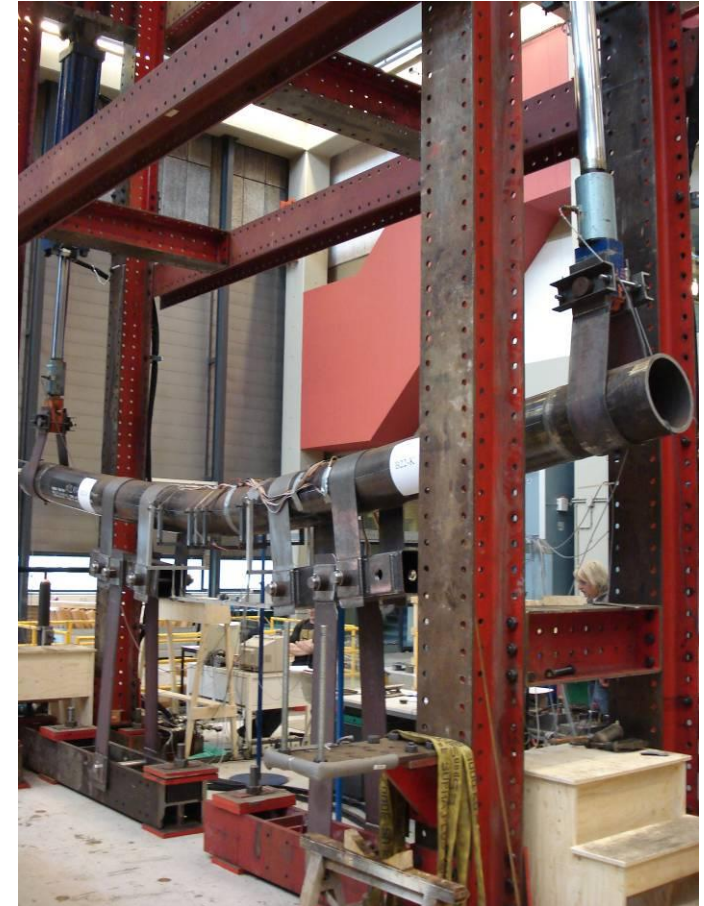
- Objective:
Identify all variables that do influence the mechanical behaviour of lined pipe during bending, and to determine their influence on this behaviour
- Bending tests
- Develop FEM models
- Validate FEM models based on test results
- Use FEM models for parameter study

Set-up and Procedures

Bending over 2%

Middle section L=1600mm

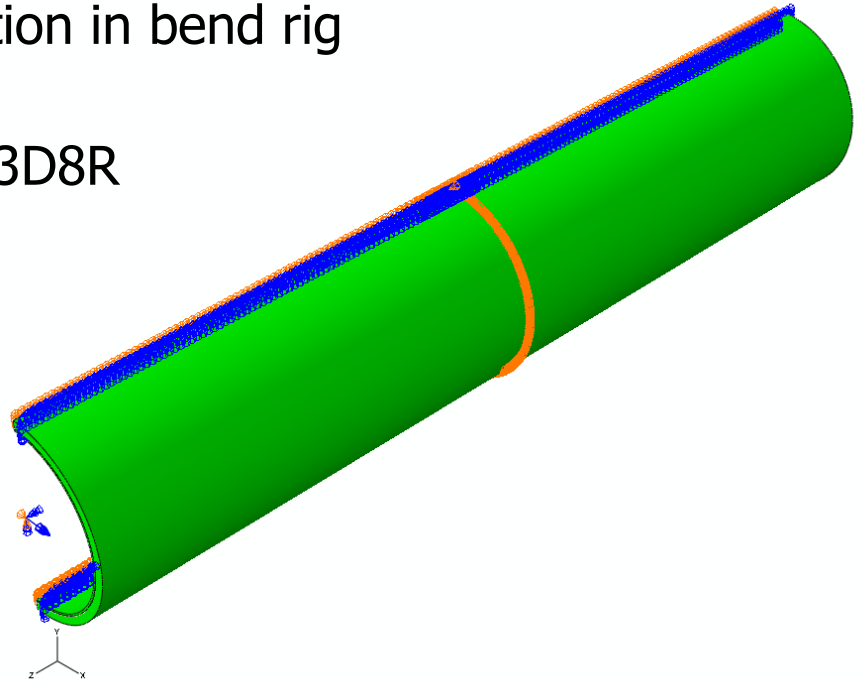
- Outer pipe:
 - Diameter: 12" (324mm outside)
 - Material: X65
 - Wall thickness: 14.3mm and 17.5mm
 - Type: ERW and seamless
 - Function: strength
- Liner:
 - Material: 316L
 - Wall thickness: 3mm
 - Function: corrosion resistance
- Girth weld: weld overlay and seal weld
- Heating cycle: coating simulation (220°C)
- Heating during bending (150°C)
- Internal pressure (20 bar)



FEM Models

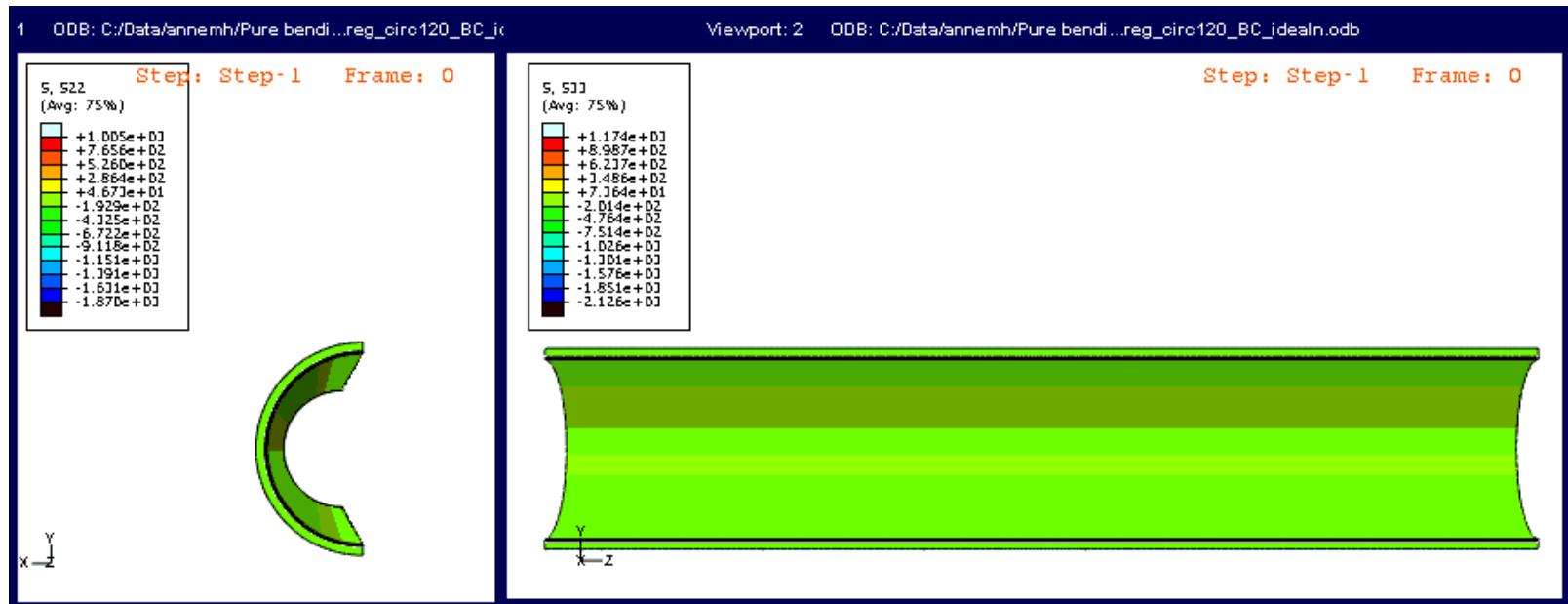
Abaqus model:

- Length 1600mm, equals midsection in bend rig
- Three layers of solid elements C3D8R
- Rotation prescribed at free ends
- Boundary conditions:
 - Ovalisation restricted at end
 - Free ovalisation at end



FEM Models

- Snug-fit lined pipe
i.e. a perfect fit



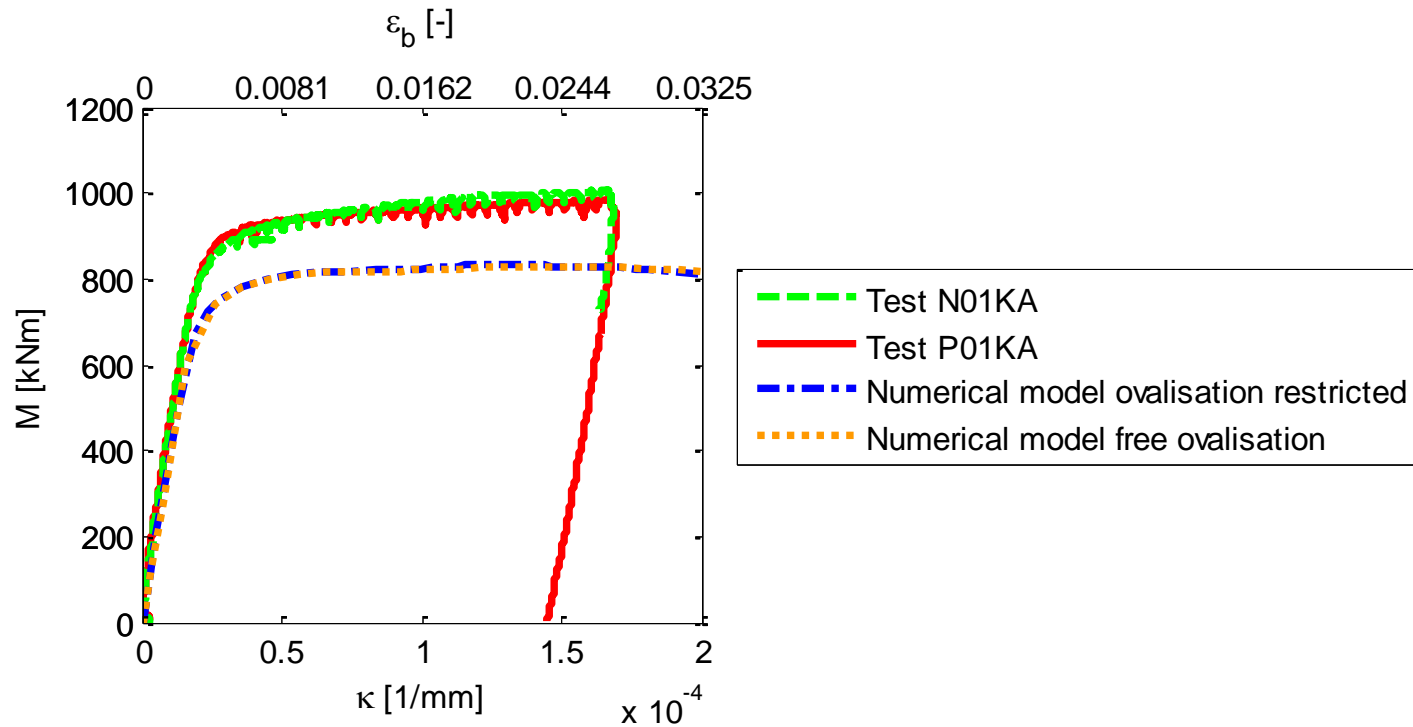
Compare tests and models

Compare FEM models with test results:

- Moment-curvature diagrams
- Axial strain-length
- Ovalisation-curvature diagrams
- Mode shapes
- Wrinkle height and length

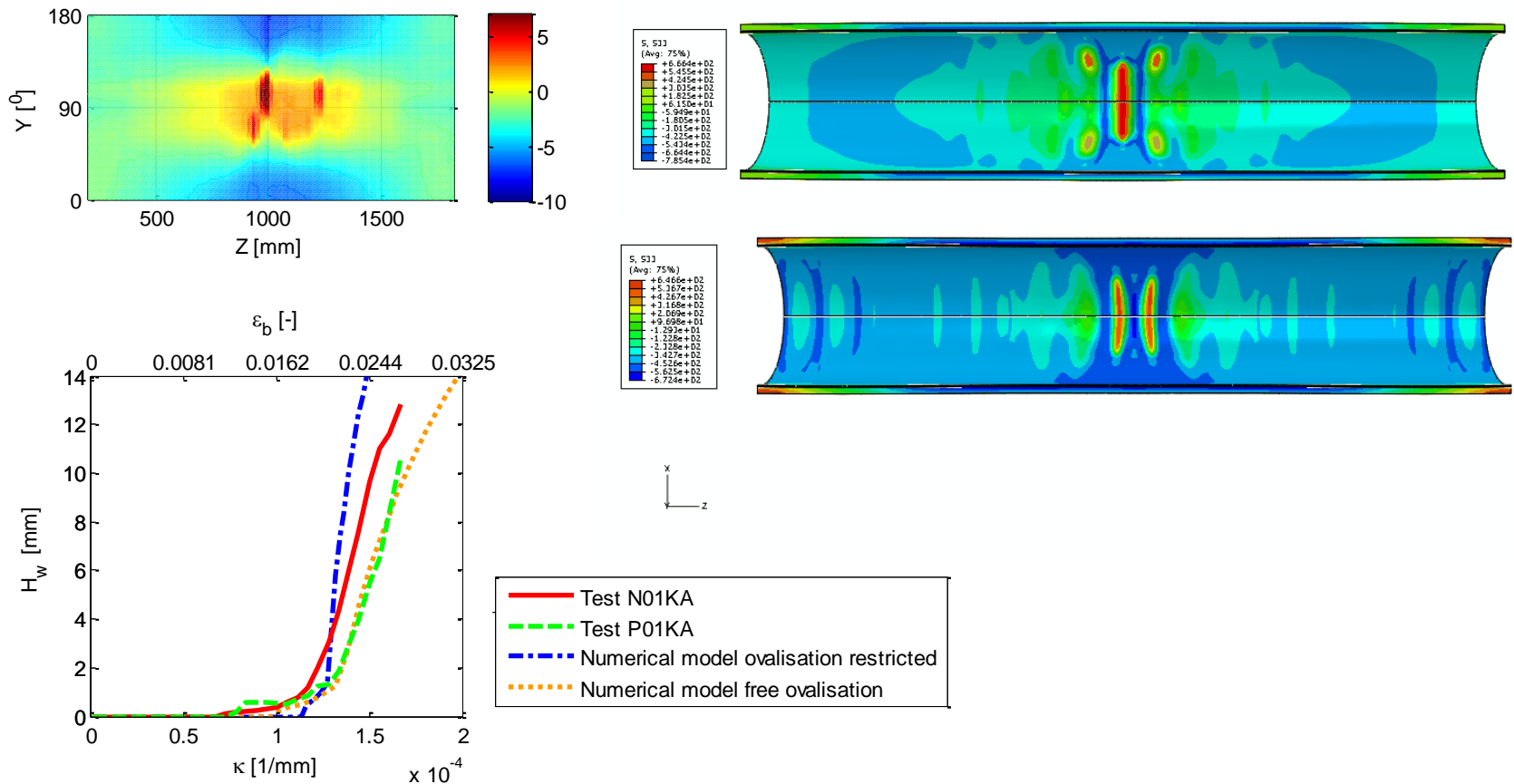
Compare tests and models

Moment-curvature diagram



Compare tests and models

Modeshape



Parameter study

Parameter study included:

- Geometry
- Material
- Contact

Parameter study

Conclusions:

- Wrinkling behaviour geometrically driven;
- Mechanical bond does have an influence, but has decreased significantly after bending.

Future work

- Determine influence of reeling
- Optimisation of lined pipe and reeling system
- Qualification

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