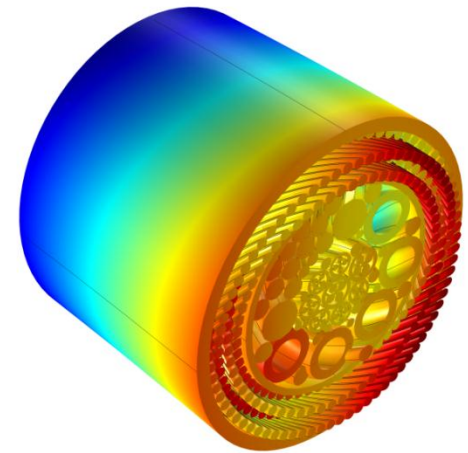
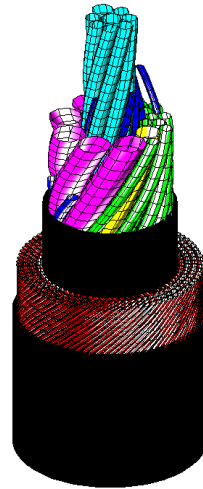
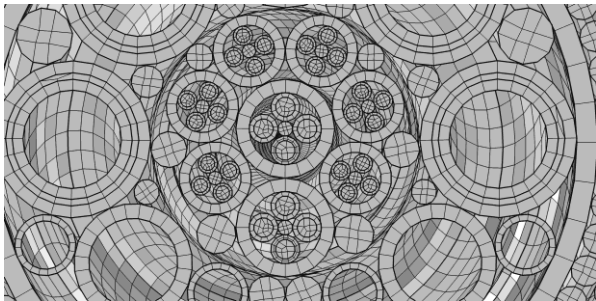




COMSOL  
MULTIPHYSICS®



## Comsol Conference 2012: Milan



# Testing and Analysing Complex Loading Conditions and Designs to Improve Subsea Cable Life

By Tim Poole

Excerpt from the Proceedings of the 2012 COMSOL Conference in Milan



# Presentation Outline



- JDR and our products
- Qualification for in-service conditions
- Cable Builder (LiveLink for Matlab™)
- Comsol Model
- Results
- Conclusions



# JDR

JDR provides:

- Subsea power cables
- Subsea production umbilicals
- Subsea power umbilicals
- Inter-array cables for offshore wind energy





# JDR Products

COMSOL  
MULTIPHYSICS® 



PROVIDING THE VITAL CONNECTION



Hartlepool, England - Quayside Facility

COMSOL  
MULTIPHYSICS® 

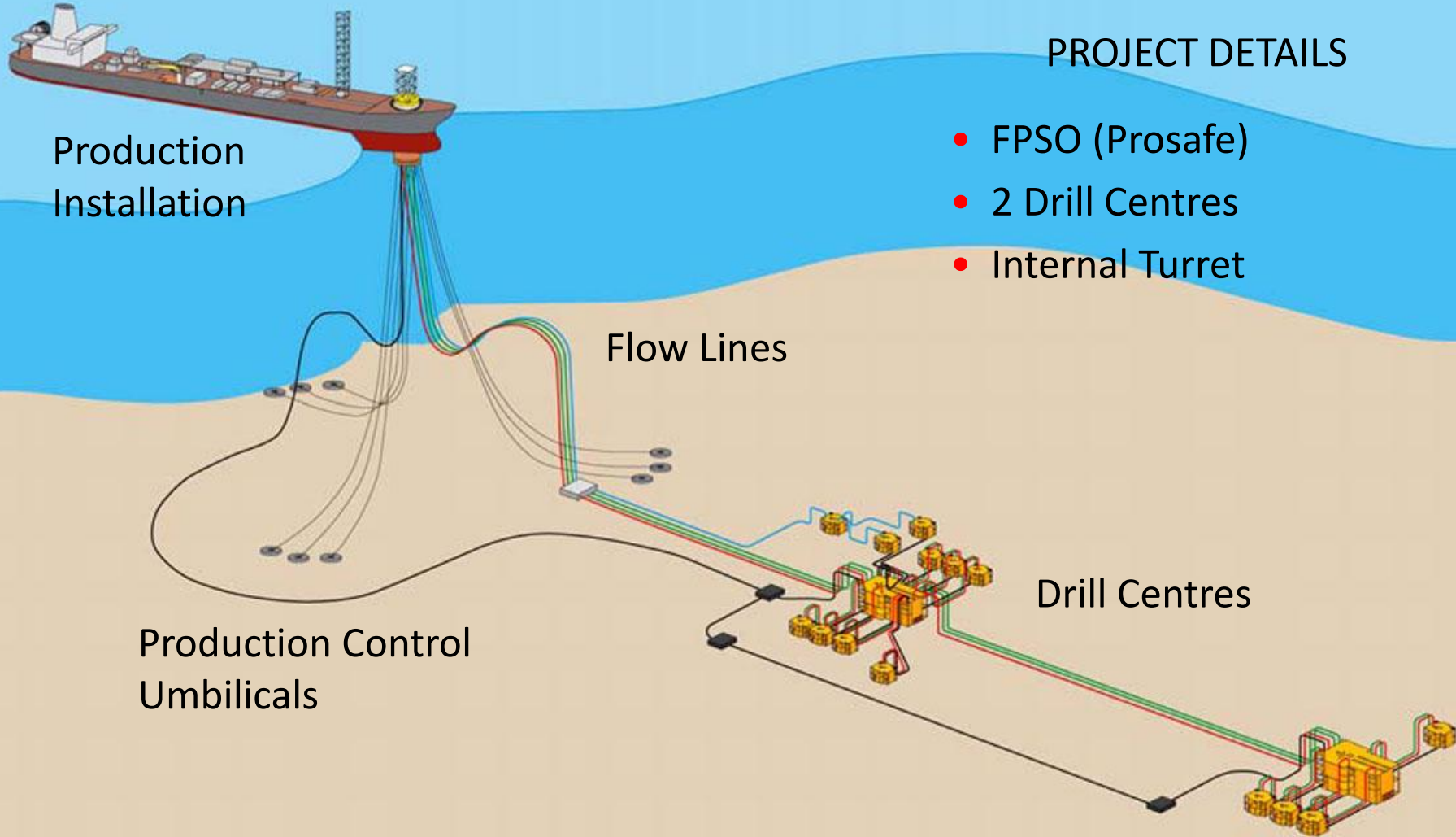


300 tonne 9.2 m Process Reels.

PROVIDING THE VITAL CONNECTION



# Umbilical in Service





# Practical Approach



Fatigue Testing



Tensile Testing

Tension: 0.5-10 te  
Pressure: – 3,000–15,000 psi  
Cycles: – 100,000  
Duration: > 1 month



## Disadvantages

- Doesn't recreate in service conditions
- Expensive
- Long Duration
- Dangerous
- Requires Manufactured Product
- Resources
- Critical path



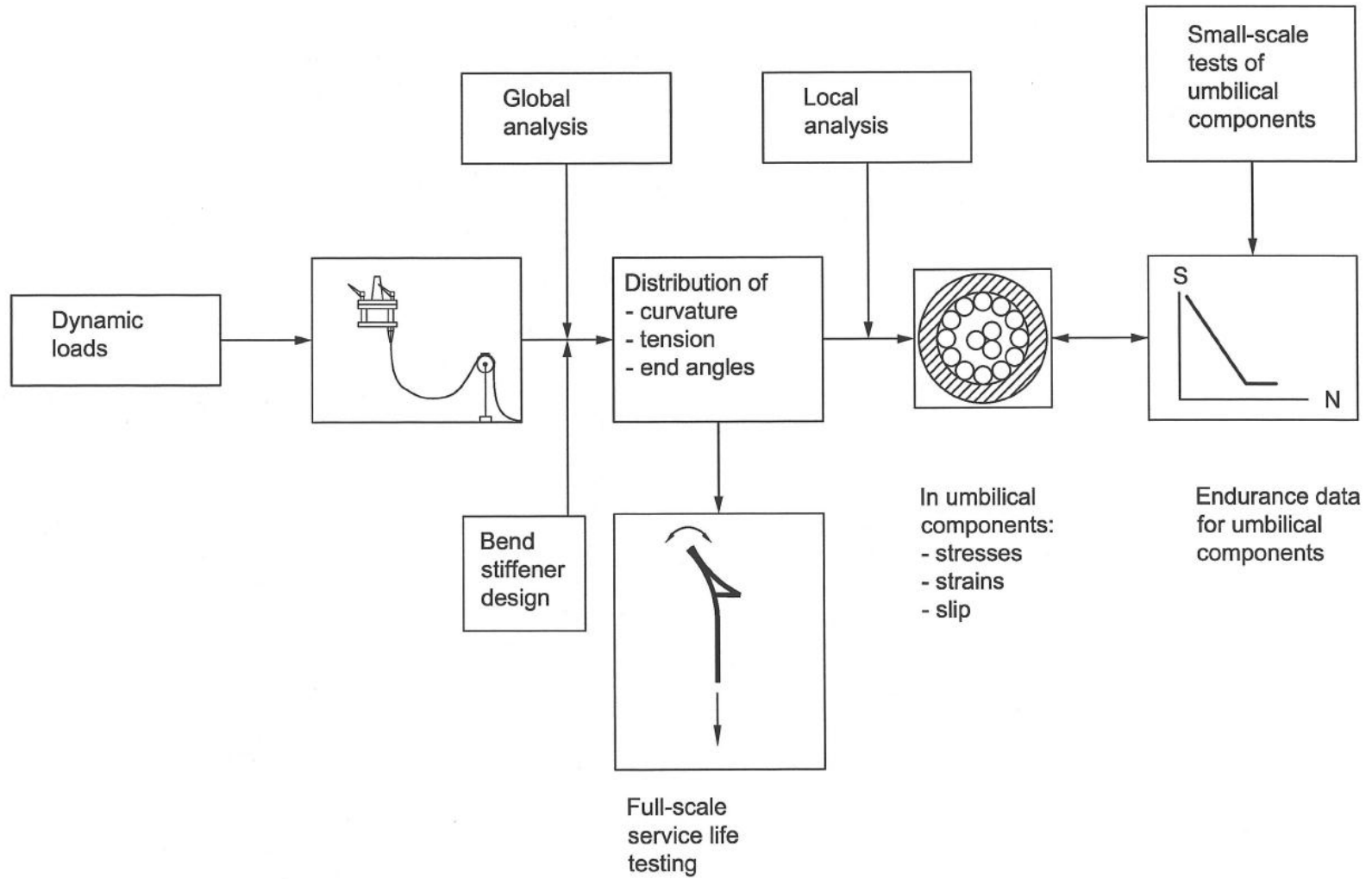


## Advantages

- Can analysis the in service conditions
- Quicker to analyse
- Can be automated
- Earlier in project
- No risk

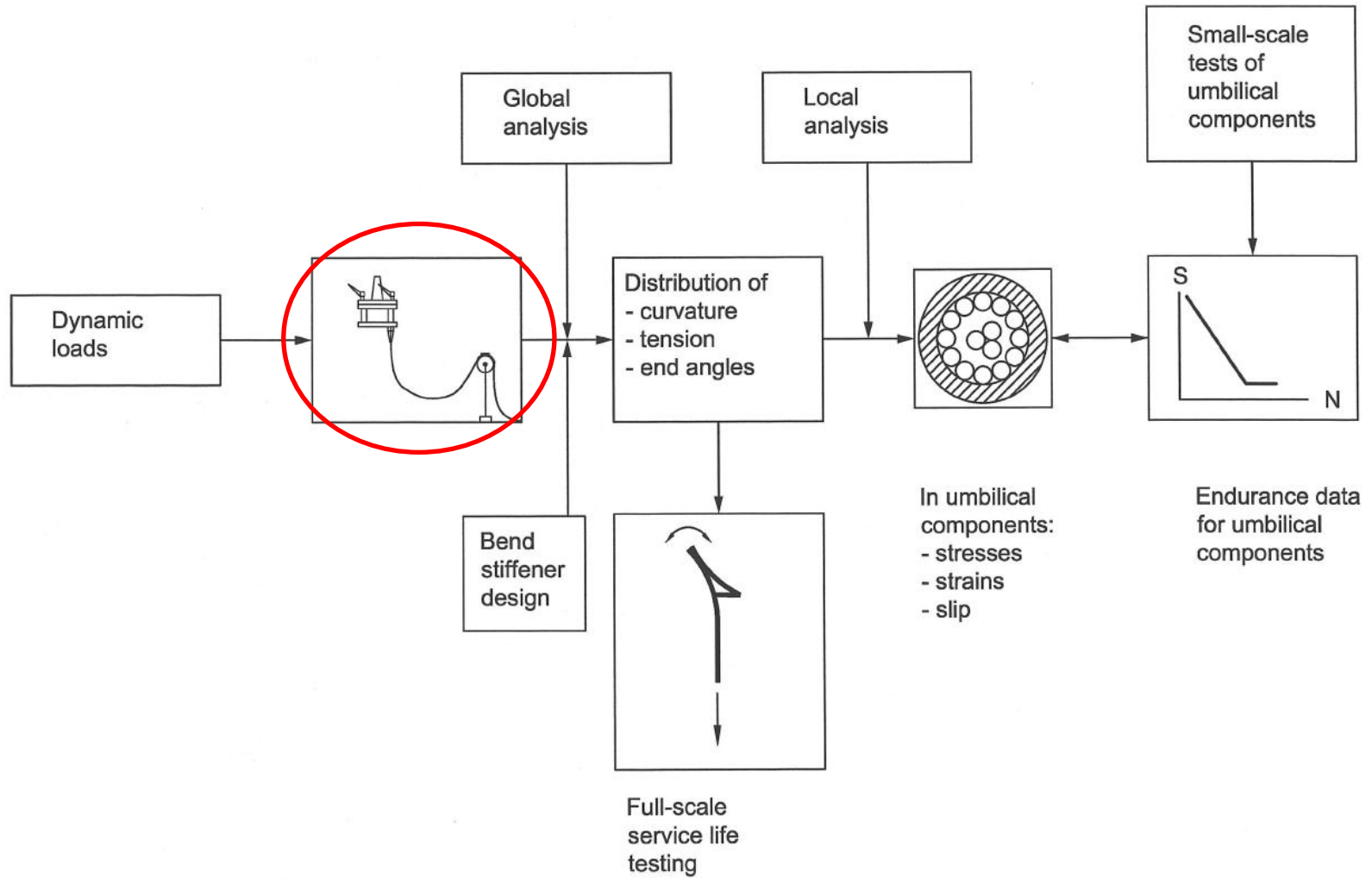


# Analysis Approach



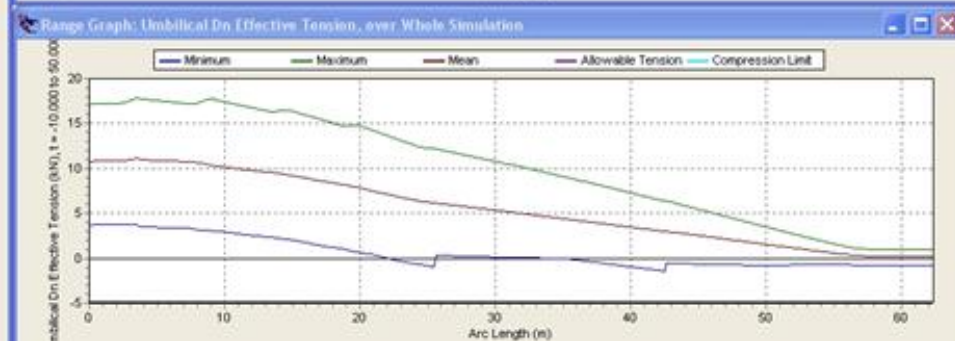
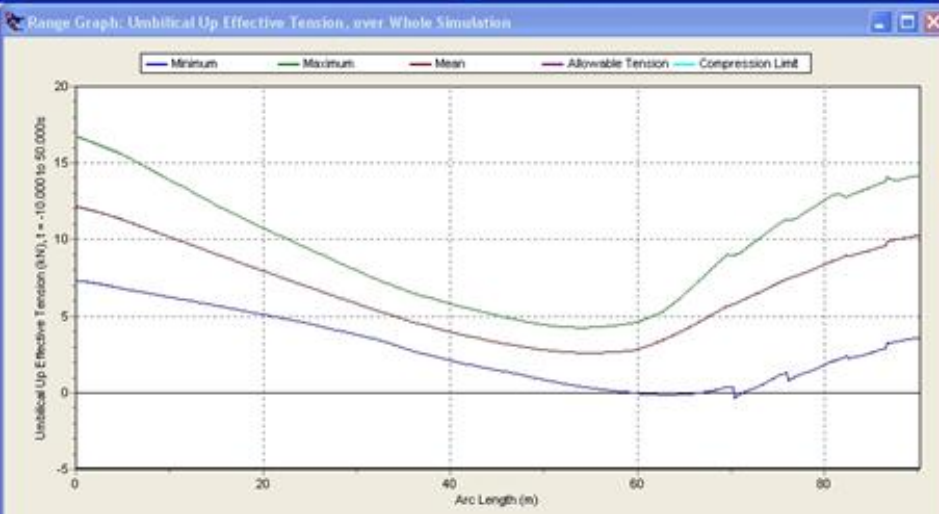
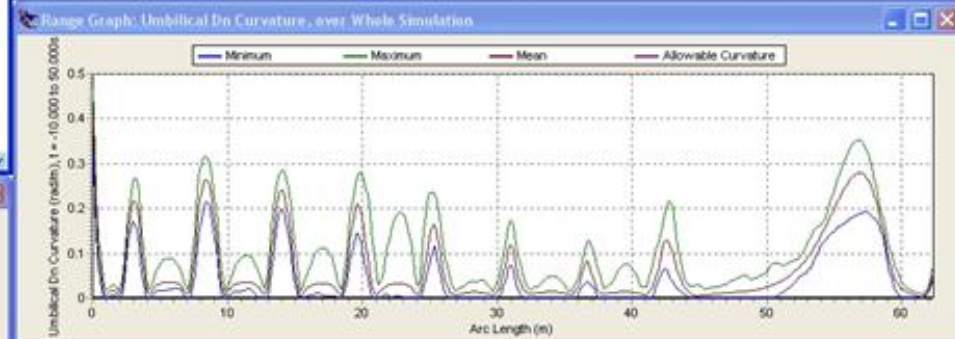
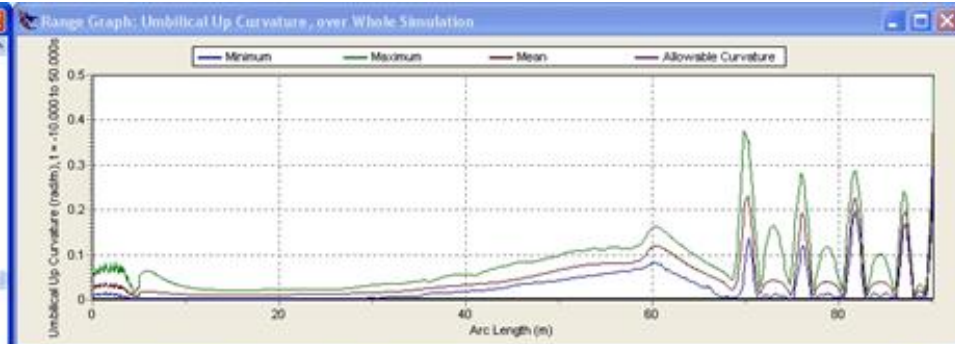
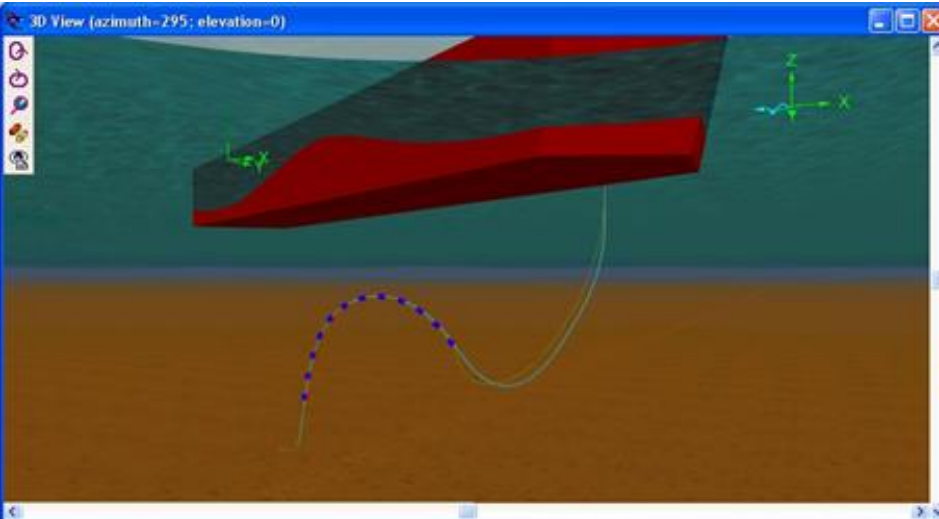


# Global Analysis



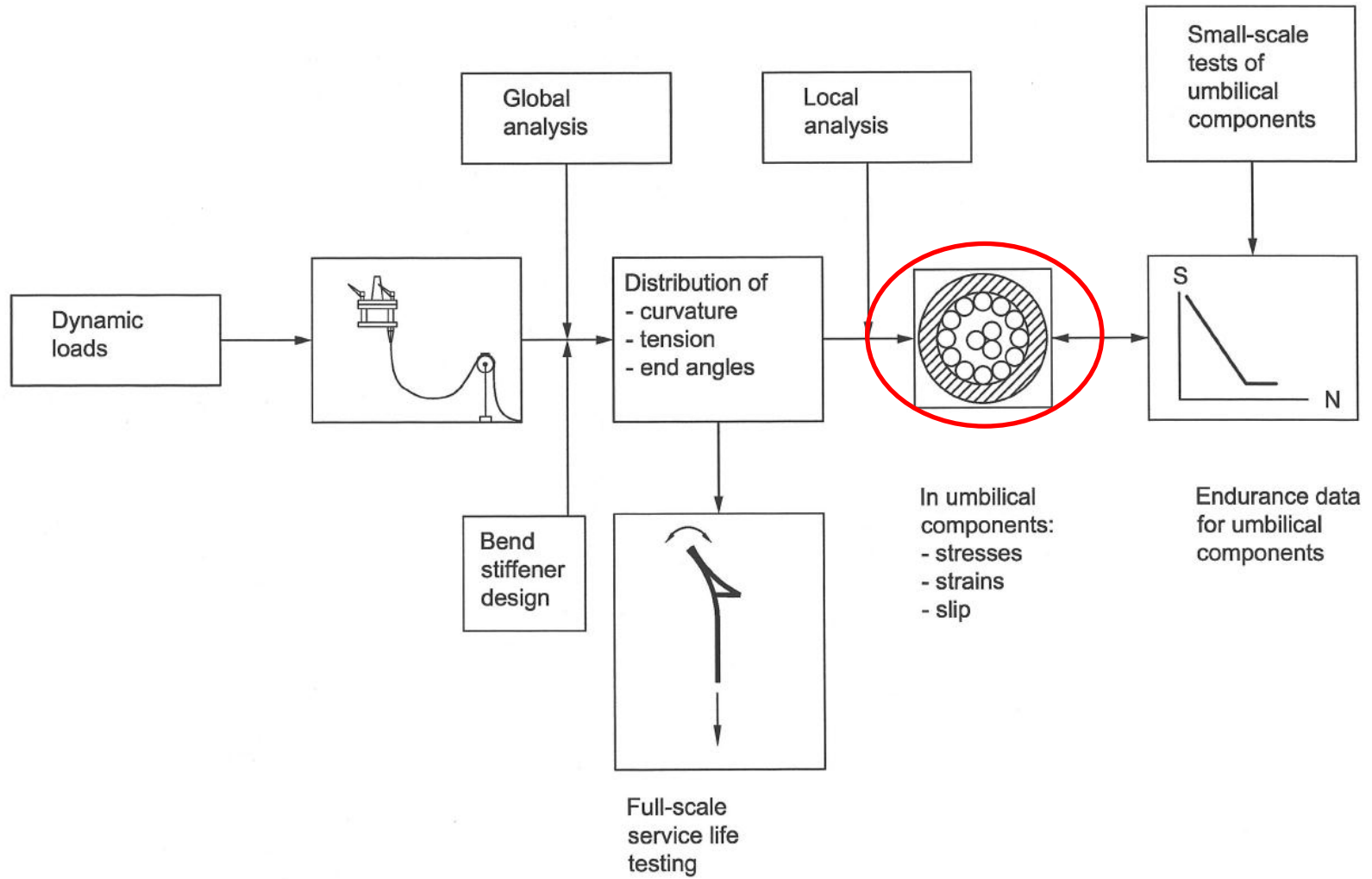


# Global Analysis - OrcaFlex<sup>tm</sup>





# Local Analysis





# Cable Detail

Water blocked Copper Conductors

Extruded Semi-conductive Layers

XLPe Insulation

Copper Tape Screen

Fibre Optics

Hoses

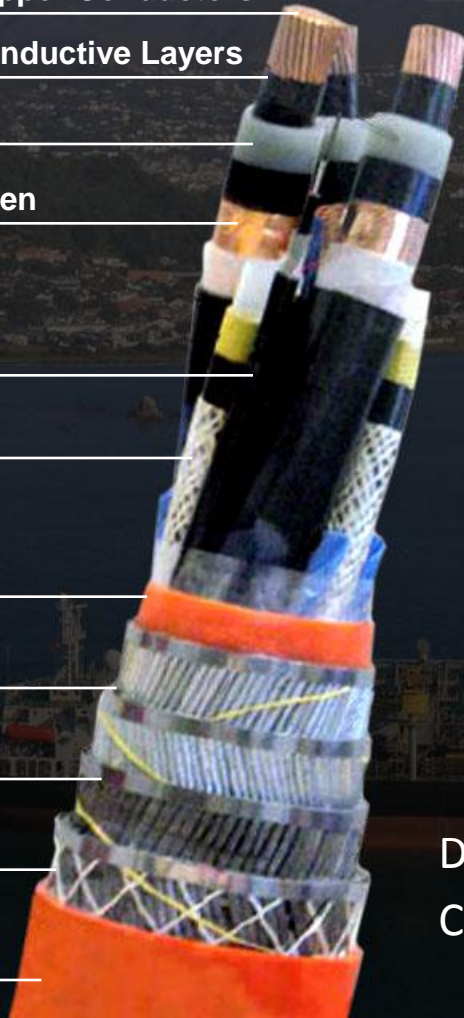
Polyethylene  
Inner Sheath

Armour Package

Ballast Package

Dynamic Braid

Polyethylene  
Outer Sheath



Power / Optical / Chemical Injection  
Composite Cable Key Data

**Voltage** : 8.7/15 (17.5kV)

**Cores** : 500mm<sup>2</sup>

**Current** : 690A

**CI Hoses** : 12.7mm ID 5,000psi

**Optical Fibres** : 16off Single Mode

**Temp** : 45 deg C

**Length** : 2095m



Dynamic Cable  
Cut-away and Slice



# Cable Properties Input

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technology development

Address: Tredomen Innovation &  
Technology Centre, Tredomen Park  
Ystrad Mynach  
Caerphilly, CF82 7FQ  
United Kingdom

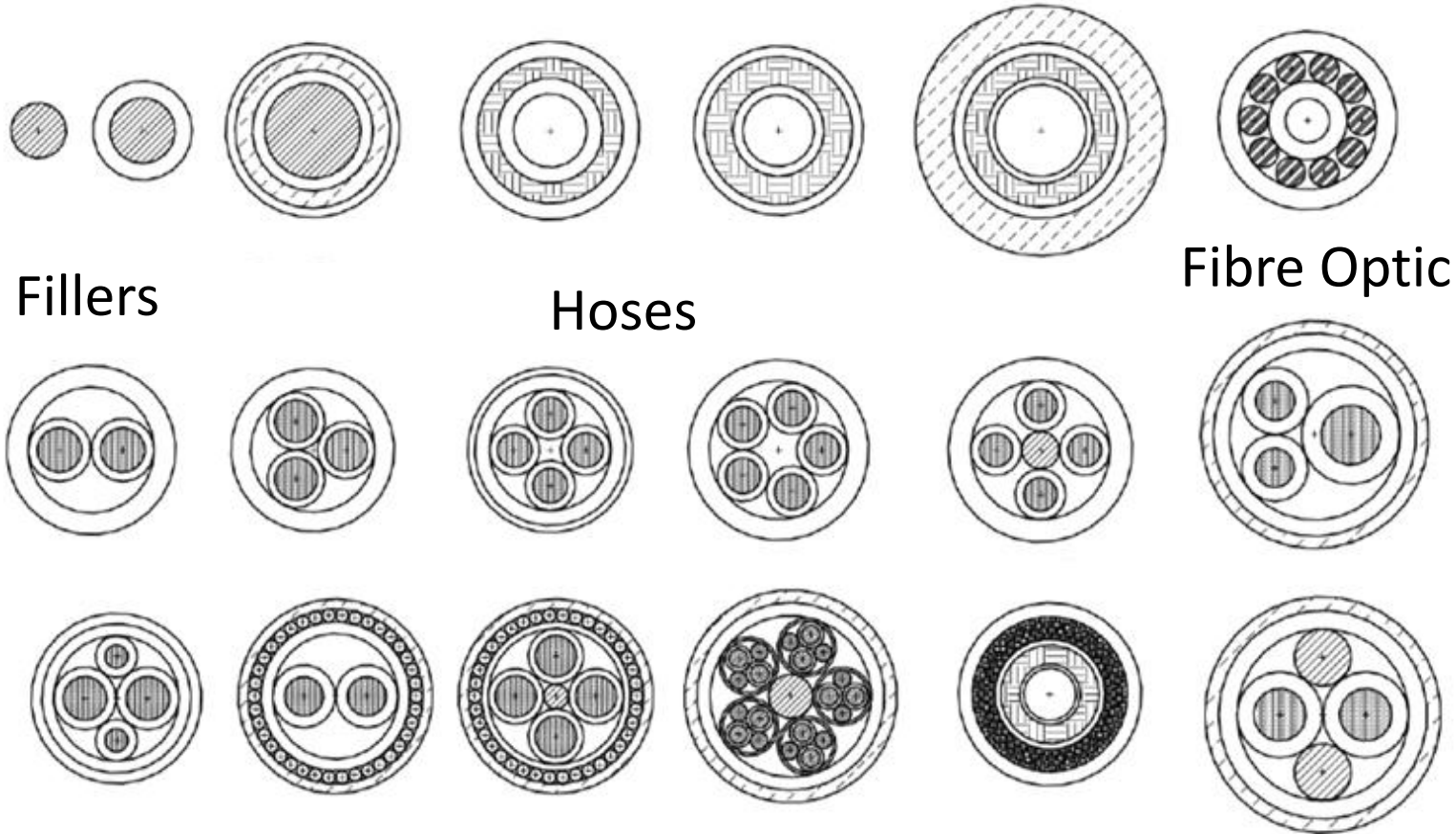
Telephone: +44 (0) 1443 866455  
TeleFax: +44 (0) 7792 901697

E-mail: [info@continuum-blue.com](mailto:info@continuum-blue.com)  
Website: [www.continuum-blue.com](http://www.continuum-blue.com)

<b>Continuum Blue Reference:</b>	JDR01-##-##						
<b>JDR Project Reference:</b>	JR####						
<b>End Client:</b>	XYZ						
<b>Date Issued to Client</b>							
<b>Drawing Reference:</b>	HU0996 Rev 00						
<b>Issue Date:</b>	29/02/12						
<b>UMBILICAL</b>							
<b>Component Description</b>	<b>Value</b> <b>Notes/Comments</b>						
Umbilical diameter (mm)	159 "+/-2.0mm"						
<b>CORE</b>							
<b>Component Description</b>	<b>Layer 1 (inner most)</b>	<b>Layer 2</b>	<b>Layer 3</b>	<b>Layer 4 (Outermost)</b>	<b>Notes/Comments</b>		
core diameter (mm)	48.23	88					
Total Number of Core Components	12	28					
Number of cables	3	1					
Number of hoses	0	13					
Number of fibre optics	0	0					
Number of fillers	9	15					
Core lay angle (deg)	9.318	13.921					
Pitch Length (mm)	1360	1360					
Rotation (CW/CCW)	CW	CCW					
<b>Armour layers/Strength Member</b>							
<b>Component Description</b>	<b>Layer 1 (inner most)</b>	<b>Layer 2</b>	<b>Layer 3</b>	<b>Layer 4</b>	<b>Layer 5</b>	<b>Layer 6 (outer most)</b>	<b>Notes/Comments</b>
Number wires	82	90					
Inner diameter of layer (mm)	130	139.94					
wire diameter (mm)	4.5	4.5					
lay angle (deg)	23.54	19.81					
Pitch Length	970	1260					
Rotation	CW	CCW					
<b>Material properties</b>							
<b>Material</b>	<b>Elastic Modulus (GPa)</b>	<b>Poison's Ratio</b>	<b>Density (kg/m3)</b>	<b>Yield Stress</b>	<b>Notes/Comments</b>		
Galvanised Steel (armour layers)	193	0.300	7800		armour		



# Component Library



Fillers

Hoses

Fibre Optic

Cables





Cable\_Generate

## CABLE BUILDER



Address: Tredomen Innovation & Technology Centre, Tredomen Park  
Ystrad Mynach  
Caerphilly, CF82 7FQ  
United Kingdom

Telephone: +44 (0) 1443 866455  
Telefax: +44 (0) 7792 901697

E-mail: info@continuum-blue.com  
Website: www.continuum-blue.com

CLICK HERE TO INPUT THE DATA FROM EXCEL SHEET

### File Name & Path Name

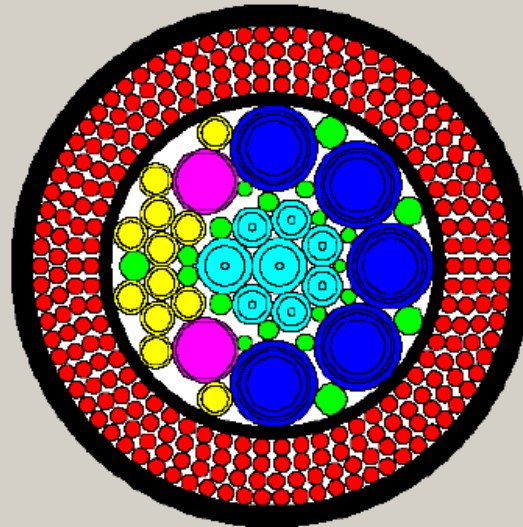
File Name :-

Path Name :-

### Type of MODEL

SYMMETRY  ROTATION  NON-SYMMETRY

**GENERATE CABLE**



Panel

armour		rope ballast	
rope ballast		filer	
core		hose	

### Input Parameters

Sheath (INNER)-Inner Ø  Sheath (OUTER)-Inner Ø

Sheath (INNER)-Outer Ø  Sheath (OUTER)-Outer Ø

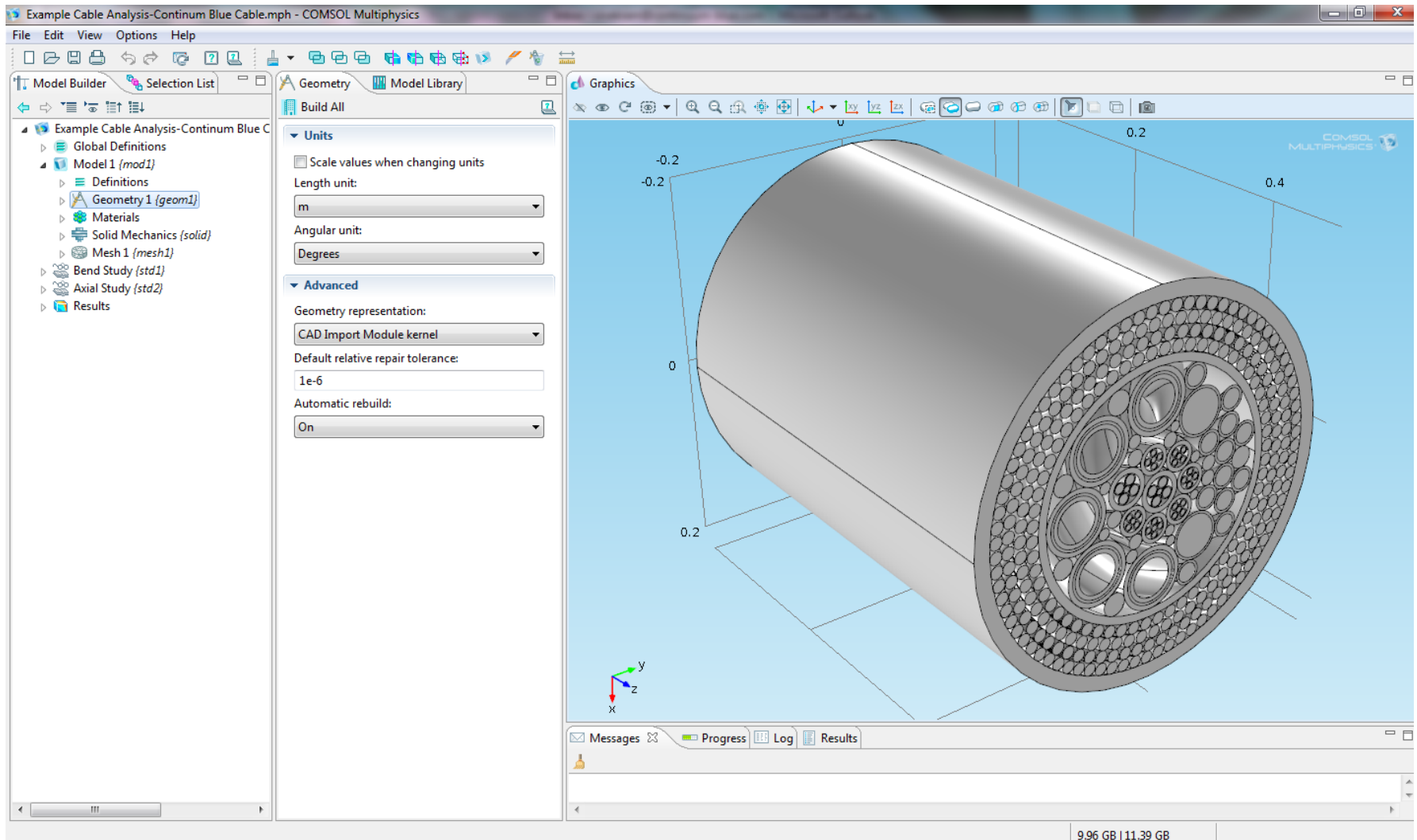
Pitch Lengths

Cable Build Length





# Comsol Model



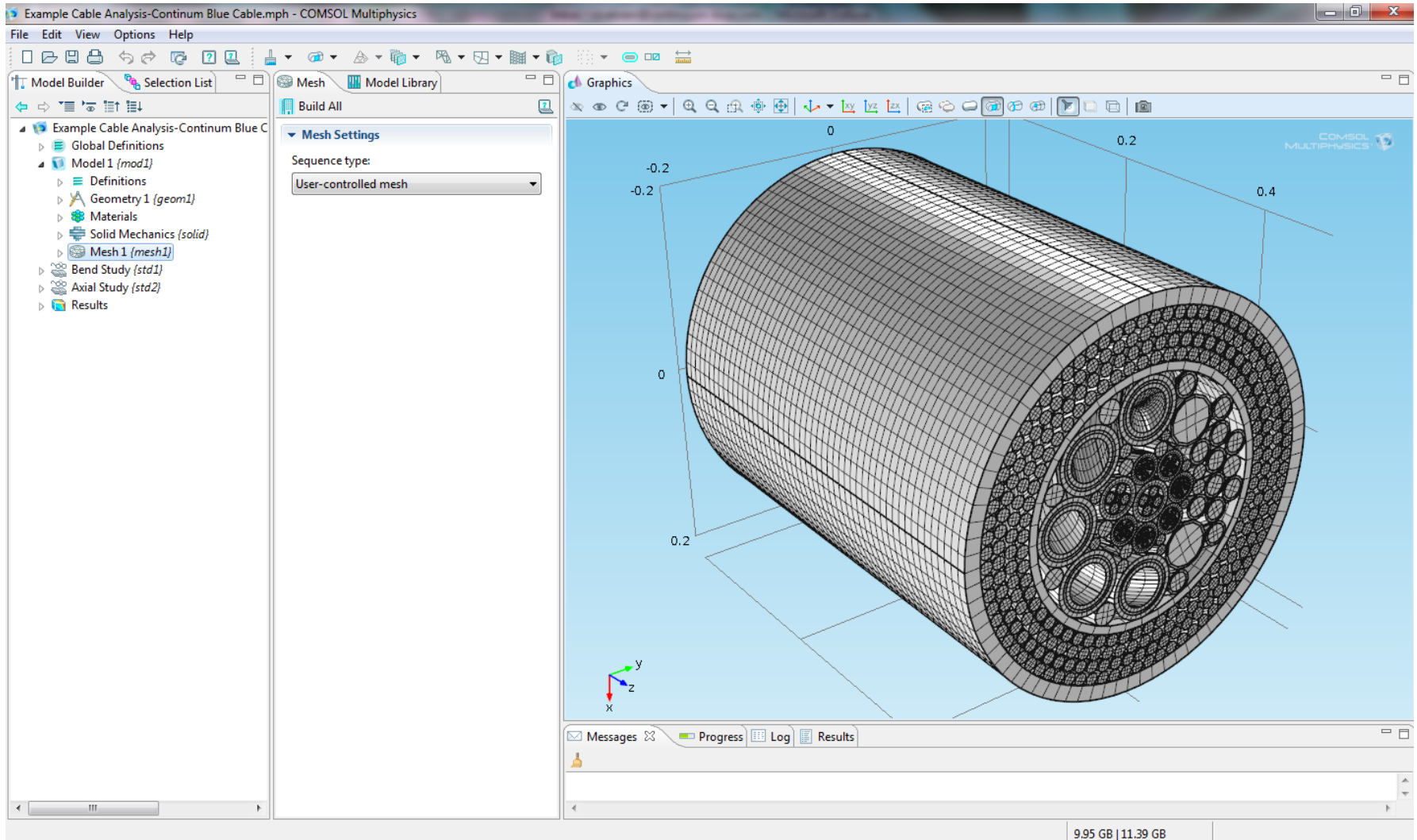
The screenshot displays the COMSOL Multiphysics software interface for a model titled "Example Cable Analysis-Continuum Blue Cable.mph". The interface is divided into several panels:

- Model Builder:** Shows a hierarchical tree of the model structure, including "Global Definitions", "Model 1 (mod1)", "Definitions", "Geometry 1 (geom1)", "Materials", "Solid Mechanics (solid)", "Mesh 1 (mesh1)", "Bend Study (std1)", "Axial Study (std2)", and "Results".
- Geometry Panel:** Contains settings for the "Build All" operation, including "Units" (Length unit: m, Angular unit: Degrees) and "Advanced" options (Geometry representation: CAD Import Module kernel, Default relative repair tolerance: 1e-6, Automatic rebuild: On).
- Graphics Panel:** Displays a 3D perspective view of a cylindrical cable cross-section. The cable has a central core with several large conductors and is surrounded by a dense mesh of smaller conductors. The model is shown in a 3D coordinate system with x, y, and z axes. Dimensions are visible, such as 0.2 and 0.4.
- Messages/Progress/Log/Results Panel:** Located at the bottom of the interface, showing the status of the simulation process.

The status bar at the bottom right indicates the memory usage: 9.96 GB | 11.39 GB.



# Mesh



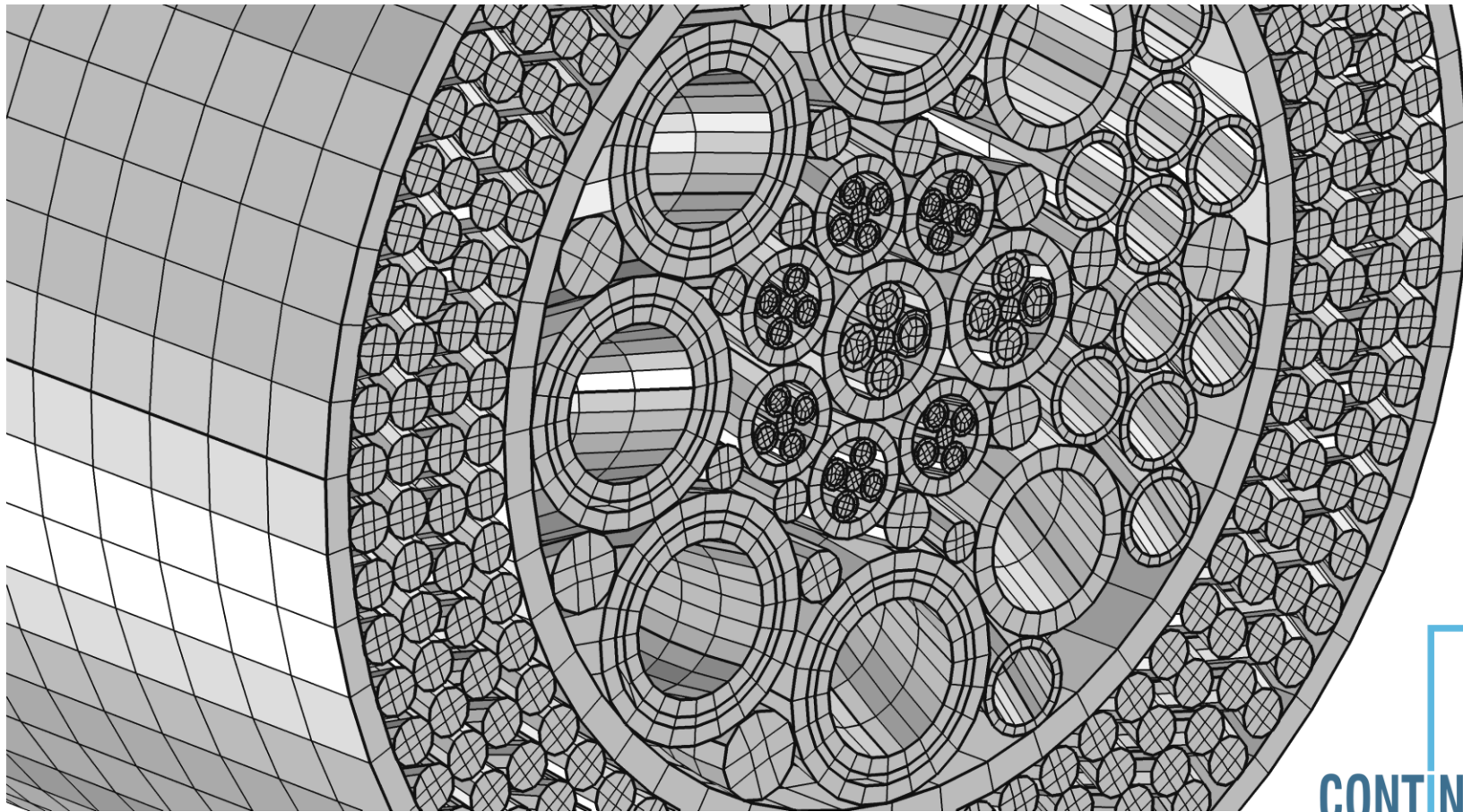
The screenshot displays the COMSOL Multiphysics software interface for a cable analysis. The main window shows a 3D model of a cable with a detailed mesh. The cable is oriented along the x-axis, with the y and z axes representing the cross-section. The mesh is composed of small, rectangular elements, with a higher density of elements in the central core of the cable. The software interface includes a menu bar (File, Edit, View, Options, Help), a toolbar, and several panels. The left panel shows the Model Builder tree, with the following structure:

- Example Cable Analysis-Continum Blue C
  - Global Definitions
  - Model 1 (mod1)
    - Definitions
    - Geometry 1 (geom1)
    - Materials
    - Solid Mechanics (solid)
    - Mesh 1 (mesh1)
    - Bend Study (std1)
    - Axial Study (std2)
    - Results

The Mesh Settings panel on the right shows the Sequence type set to "User-controlled mesh". The Graphics window displays the 3D model with a coordinate system (x, y, z) and numerical values for the axes: x ranges from -0.2 to 0.2, y from -0.2 to 0.2, and z from 0 to 0.4. The bottom status bar indicates the memory usage: 9.95 GB | 11.39 GB.



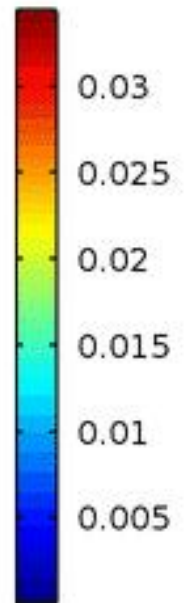
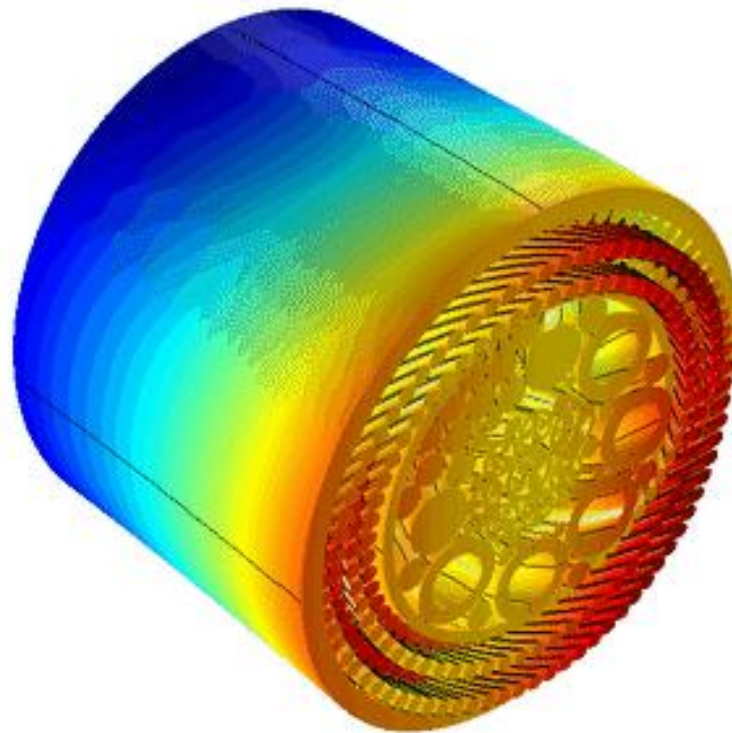
# Mesh (cont.)



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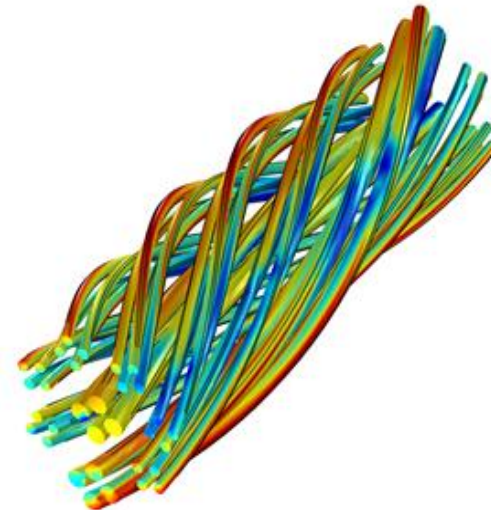
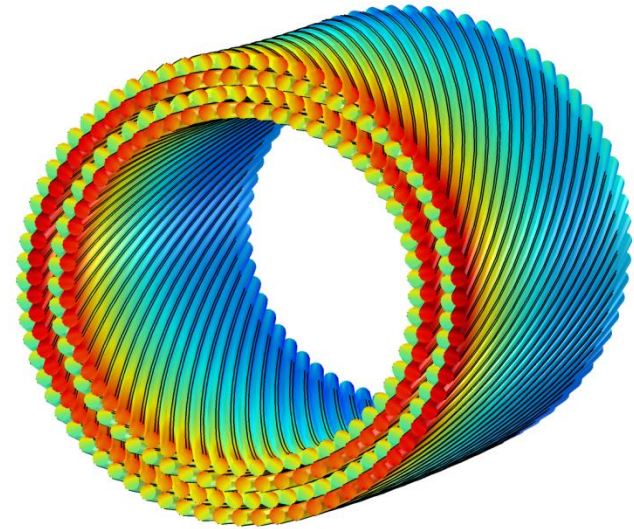
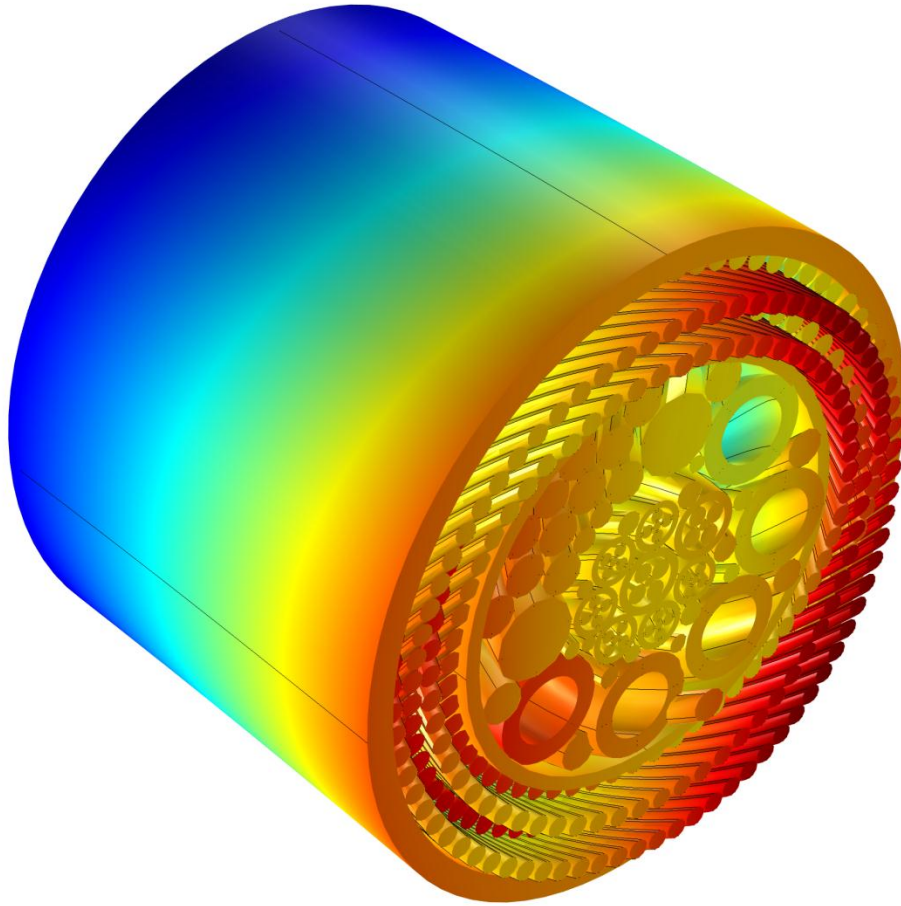


# Results





# Results

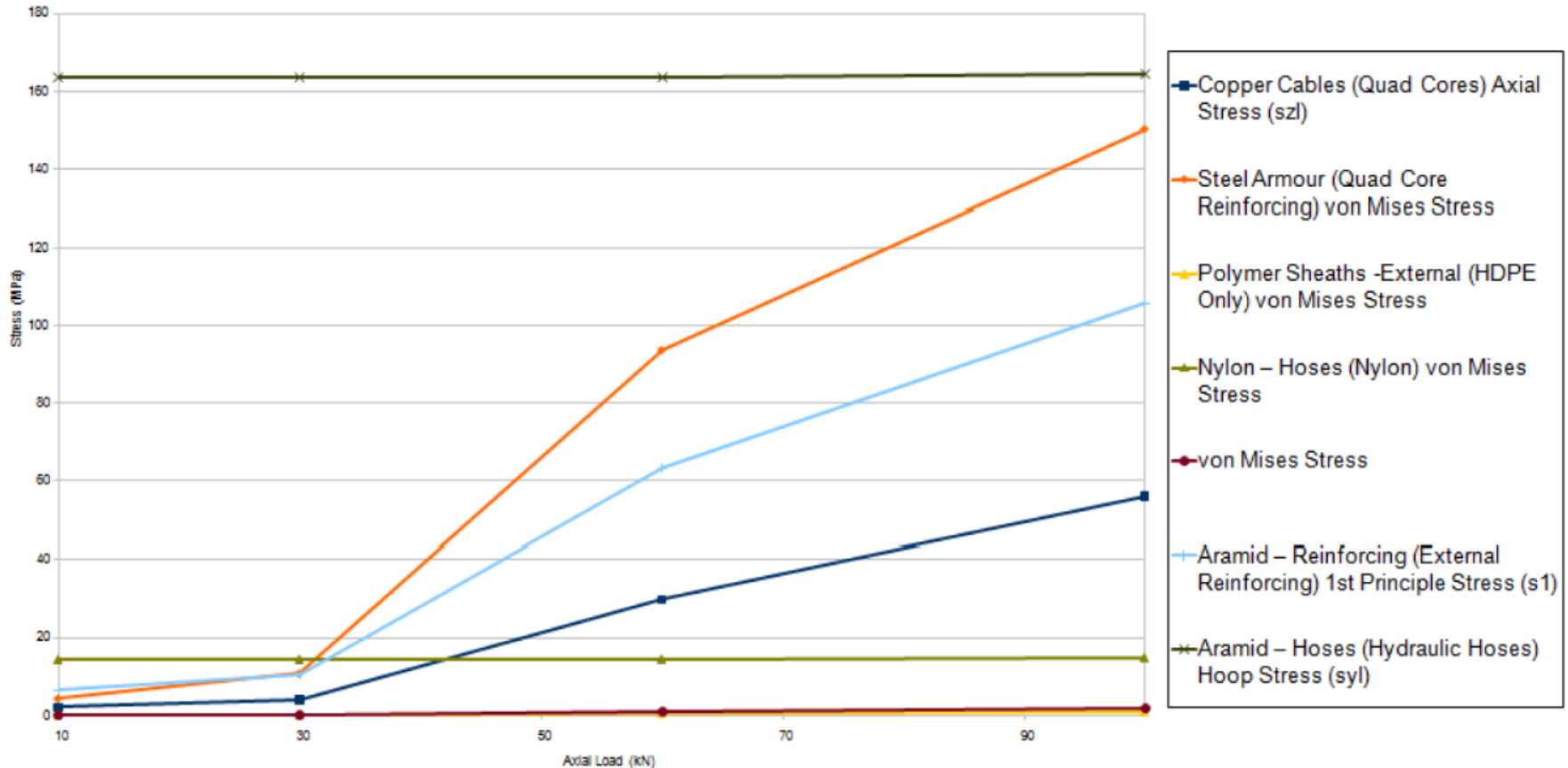


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technology development



# Results – Components (Axial)

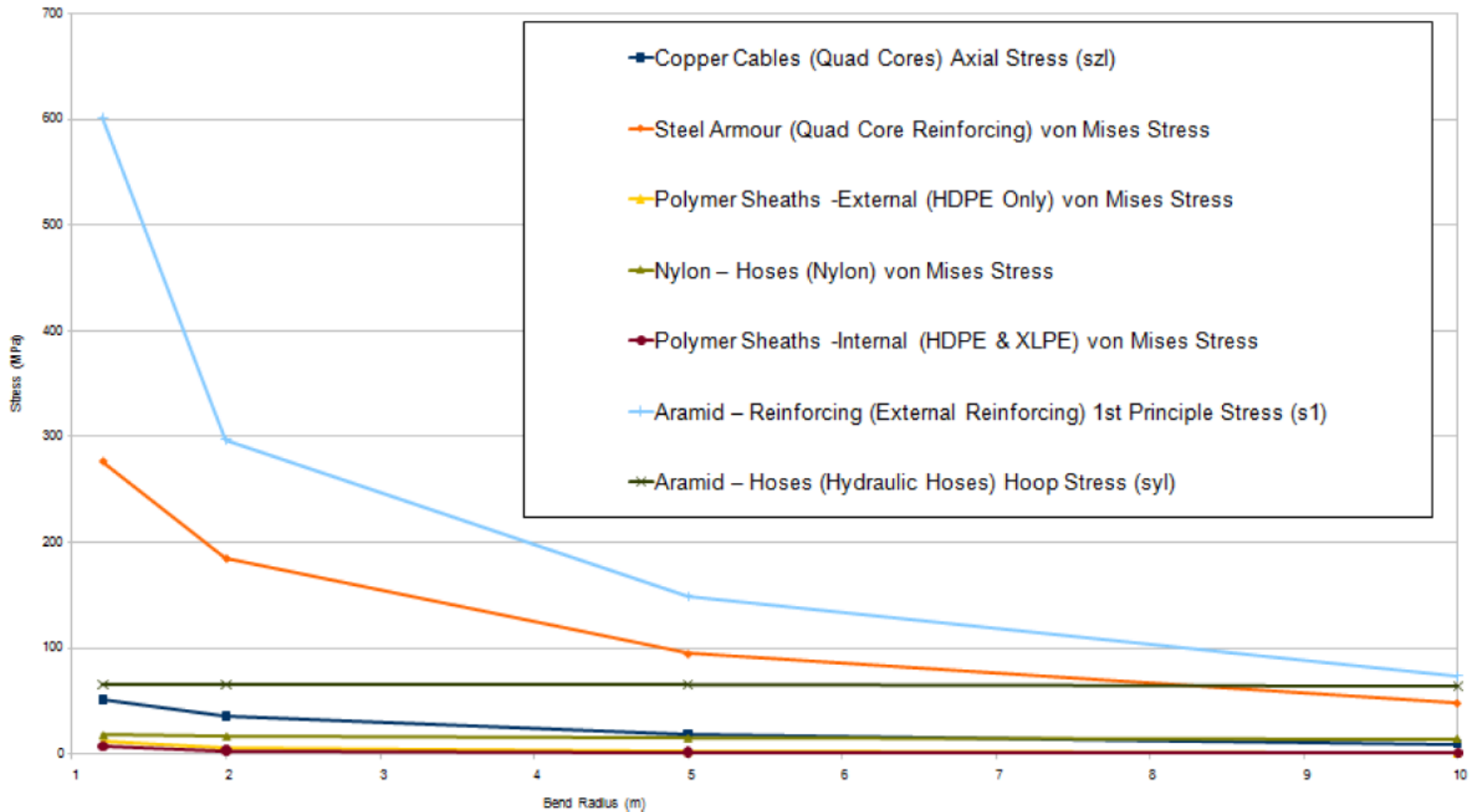
Graphical Representation of Average von Mises, 1st Principal, Axial & Hoop Stress Data for Various Axial Loads





# Results – Components (Bending)

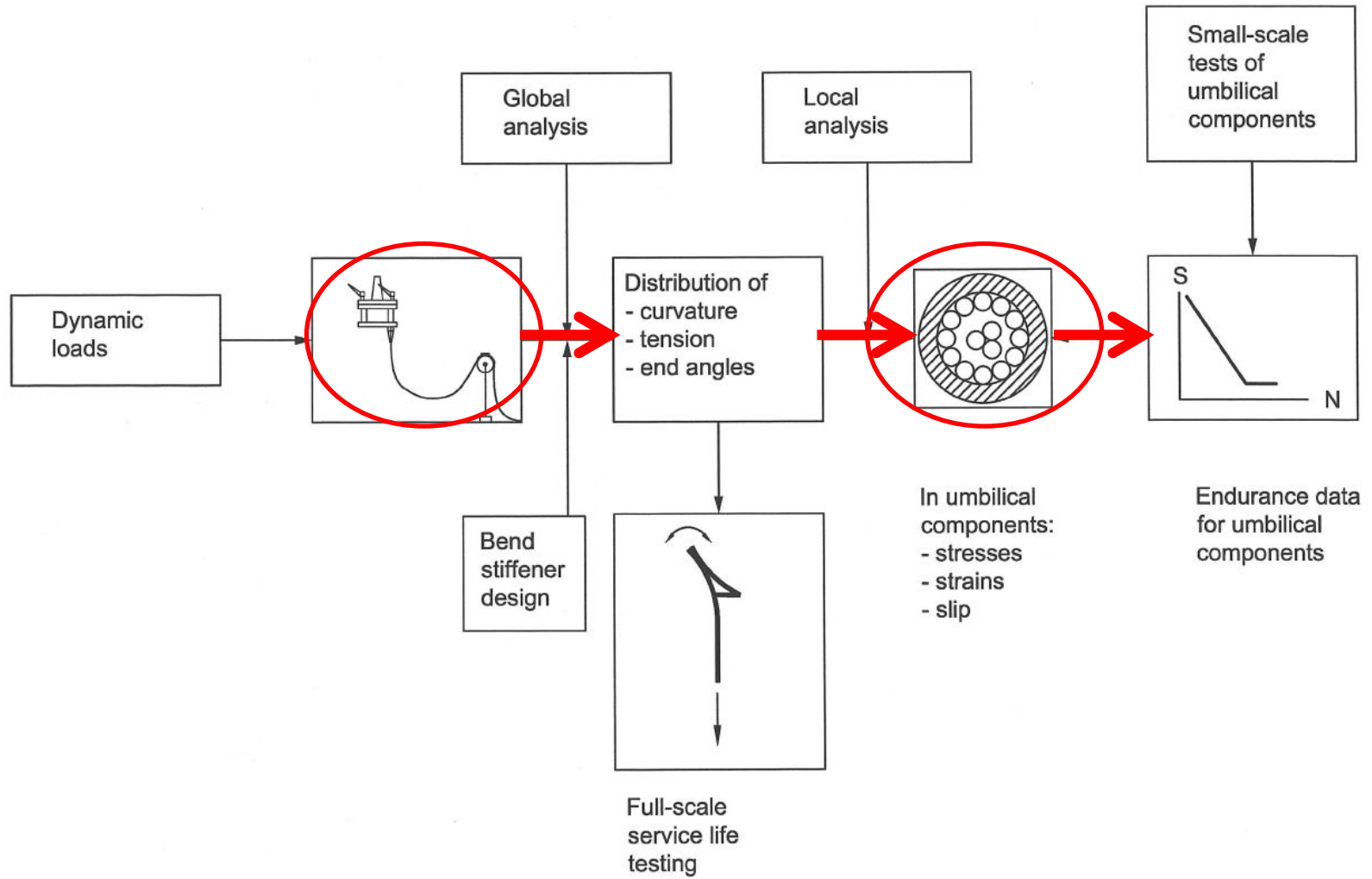
Graphical Representation of Average von Mises, 1st Principal, Axial & Hoop Stress or Various Axial Loads







# Results





# Conclusion

- Quicker
- Cheaper
- Can Be Conducted Earlier
- Automated Workflow