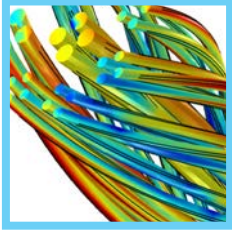


SUBSEA CABLE, UMBILICAL & HUB SERVICES

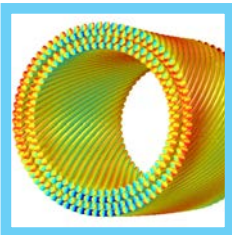
• CABLE/UMBILICAL CHARACTERISTICS

- CAPACITY CURVES (TENSION VS CURVATURE)
- ALLOWABLE CRUSHING LOADS
- MECHANICAL STIFFNESS (AXIAL, BEND, TORSION)
- CROSS SECTION DAMPING (HYSTERESIS & EFFECTIVE DAMPING)



• STRESS & FATIGUE ANALYSIS

- STRESS-STRAIN, DISPLACEMENT & DEFORMATION
- SLIP CHARACTERISTICS OF INTERNAL STRUCTURES
- CONTACT PRESSURES & DISTRIBUTIONS
- FATIGUE ANALYSIS & LIFE CALCULATIONS

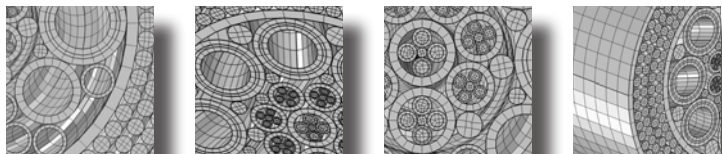


• MATERIAL SELECTION & CHARACTERIZATION

- ORTHOTROPIC MATERIALS (ARAMID REINFORCING)
- NONLINEAR MATERIALS (METAL ALLOYS & RUBBER LIKE POLYMERS)
- FATIGUE CURVES (MATERIAL, THERMAL & FRETTING)
- SELECTION & OPTIMISATION

• MISCELLANEOUS SERVICES

- HUB DESIGN & OPTIMIZATION
- BESPOKE CABLE GEOMETRIES & COMPONENTS



ADVANCED MULTIPHYSICS MODELLING

As COMSOL Certified Consultants, Continuum Blue offers advanced multiphysics analysis services to clients developing subsea cables & umbilicals. We can provide, stress-strain, thermal & fatigue simulations under various load conditions; aiding in the detection of potential design flaws & predicting long term fatigue damage & forecast cable service life.

From client supplied project specifications & drawings, a complete 3D subsea cable or umbilical section is generated for analysis (FIGURES 1 & 2).

UMBILICAL			
Component Description	Value	Notes/Comments	
Umbilical diameter (mm)	120	±2.0mm	
CODE			
Component Description	Layer 1 (inner)	Notes/Comments	
Umbilical diameter (mm)	80		
Total Number of Core Components	10		
Number of cables	4		
Number of fibres	3		
Number of fibre optics	2		
Number of fibres	1		
Core by weight (%)	100		
Pitch Length (mm)	300		
Reserve (CONDUCTOR)	0.0		
Armour layers/Strength Member			
Component Description	Layer 1 (inner)	Layer 2	Layer 3
Number wires	80	80	40
Inner diameter of layer (mm)	90	70	30
Umbilical diameter (mm)	3	3	4
by weight (%)	100	100	100
Pitch Length (mm)	300	300	300
Reserve (%)	0.0	0.0	0.0

FIGURE 1: SAMPLE SECTION OF PROJECT SPECIFICATION SHEET FOR MODEL GENERATION

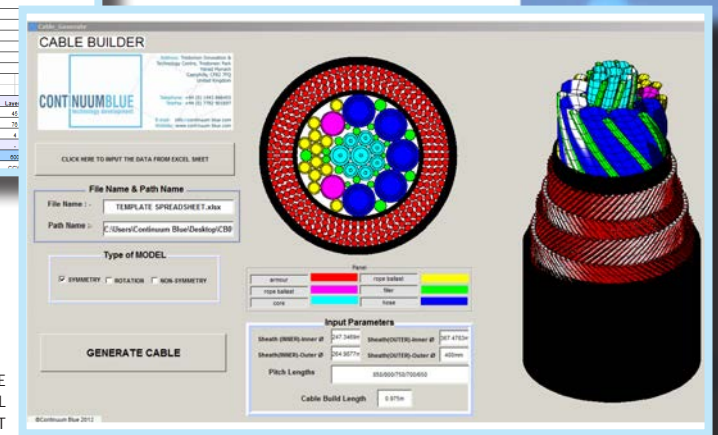


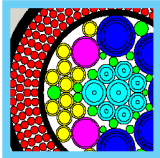
FIGURE 2: SCREEN SHOT OF INHOUSE SOFTWARE TO GENERATE FEA MODEL BASED ON SPECIFICATION SHEET

Cable & umbilical structures can include various features, such as:

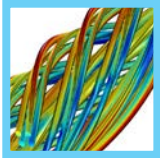
- ARMOUR CABLES (4 OR MORE)
- WOVEN OR BRAIDED STRUCTURES (SUCH AS ARAMID BRAIDED STRUCTURES)
- COMPOSITE MATERIALS (ANISOTROPIC & ORTHOTROPIC MATERIALS)
- SUB-CABLE STRUCTURES (FIBRE OPTICS, POWER & MULTI-CORES)
- CORRUGATED STRUCTURES

Analysis of the cables or umbilicals, can include:

- SINGLE OR COMBINED LOADS



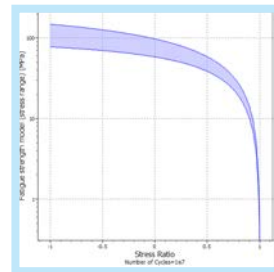
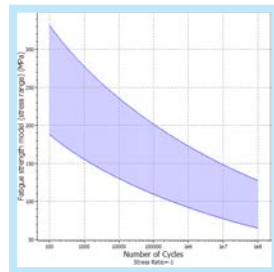
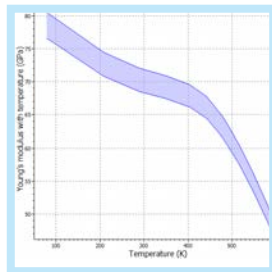
- BENDING, AXIAL TENSION & ELECTRICAL LOADING
- FULL CONTACT ANALYSIS
 - BETWEEN COMPONENTS, REINFORCING ARMORS & OTHER STRUCTURES
- EQUATION BASED MODELS & CONSTRAINTS
- RANGE OF OUTPUTS (FIGURES 7, 8 & 9):
 - CAPACITY CURVES (TENSION VS CURVATURE)
 - CROSS-SECTION DAMPING (HYSTERESIS & EFFECTIVE DAMPING)
 - STRESS & STRAIN, DISPLACEMENTS & DEFORMATIONS
 - MECHANICAL STIFFNESS (AXIAL, BEND & TORSION)
 - SLIP CHARACTERISTICS BETWEEN INTERNAL STRUCTURES
 - PLASTIC & PERMANENT DEFORMATION ON YIELDING STRUCTURES
 - CONTACT PRESSURES & DISTRIBUTIONS
 - REACTION FORCES & STRAIN ENERGY



ADVANCED MATERIAL MODELLING & CHARACTERISATION

Continuum Blue has the capability to assess & implement advanced material types into the cable analysis, such as:

- ELASTO-PLASTIC FOR DUCTILE MATERIALS
 - NONLINEAR HARDENING FUNCTIONS EG. RAMBERG-OSGOOD FUNCTION FOR COPPER ALLOYS (FIGURE 3)
- HYPER-ELASTIC MATERIALS & RUBBER LIKE MATERIALS
 - MOONEY-RIVILIN & OGDEN STRAIN ENERGY MATERIAL MODELS
- ANISOTROPIC & ORTHOTROPIC MATERIAL
 - COMPOSITES MATERIALS
 - WOVEN STRUCTURES SUCH AS KEVLAR® REINFORCING
- FATIGUE PROPERTIES & S-N CURVES
 - FRETTING, MATERIAL & THERMAL FATIGUE CURVES (FIGURES 4 & 5)



FIGURES 3, 4 & 5: STRESS VS. TEMPERATURE, S-N CURVE & FATIGUE STRESS VS. STRESS RATIO OF COPPER ALLOY

FIGURE 6: MATERIAL FRACTURE TOUGHNESS VS. TEMPERATURE FOR MATERIAL SELECTION & OPTIMISATION

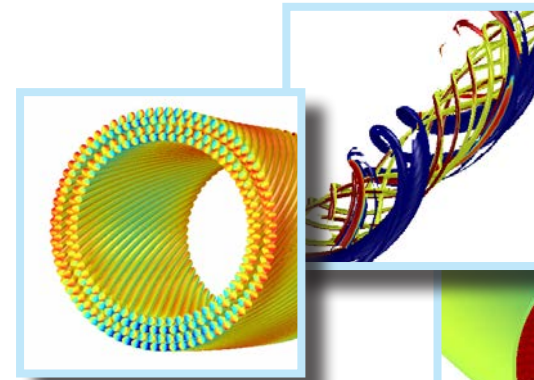
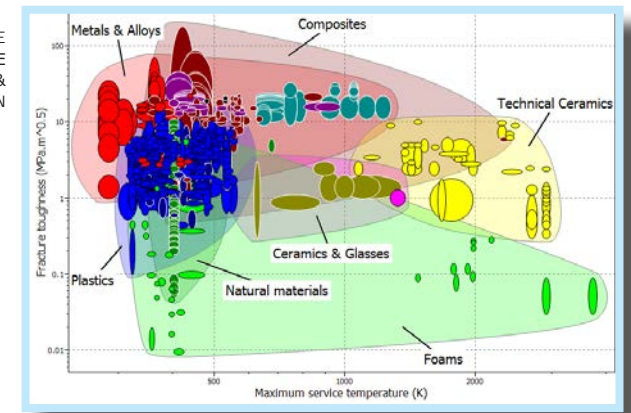


FIGURE 8: STRESSES ON ARMOURS

FIGURE 7: CONTACT PRESSURE ON SUBCABLE PARTS DURING BEND LOAD CASE

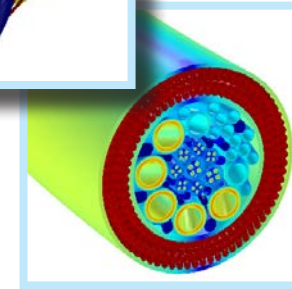
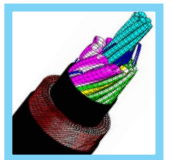
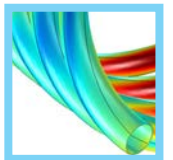


FIGURE 9: STRESS ON CABLE SECTIONS DURING AXIAL LOADING



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