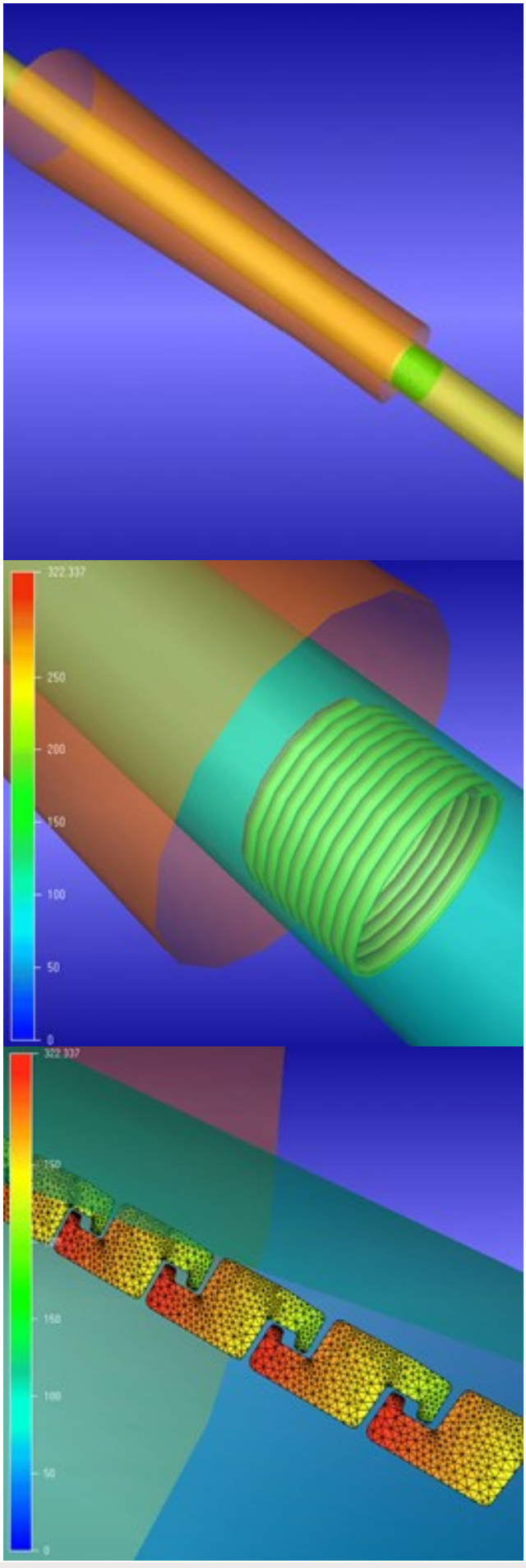
SINTEF

BFLEX for flexibles

The BFLEX program system is a special-purpose computer tool developed for analysis of bonded and non-bonded flexible pipes under in-service load conditions.



MAIN FEATURES

For non-bonded flexible pipes, BFLEX is widely used for extreme stress analysis and fatigue assessment of tensile and pressure armor wires. The non-linear behavior of the flexible pipes under complicate load conditions can be precisely predicted and this is has also been verified by full scale laboratory measurements with excellent agreement.

External accessories such as bend stiffener, bell mouth and roller can also be included in BFLEX model.

Local buckling of tensile armors under combination of axial compressive load and cyclic bending can also be predicted by BFLEX.

CAPABILITIES

- Layer by layer definition of flexibles
- Elasto-plastic material properties
- Prediction of physical properties EA, EI and GJ
- Stress analysis and fatigue assessment of tensile and pressure armor wires

KEY RESULTS

- Strain or stress of functional components
- Non-linear relation of curvature and bending moment
- Individual stress component including friction stress
- Contact pressure due to axisymmetric load
- Ovalization of carcass layer
- Fatigue damage on all metallic components
- Cross section rotation under compression and cyclic bending

BENEFITS

- Full FE modelling of flexibles, extremely efficient in computing time compared to general FE software
- Real load conditions as in service, accumulated damage on all nodes for all global sea states
- Moment curvature relation validated by full scale measurements, stresses validated by using Fiber Bragg Grating technique embedded in tensile armor wires
- Both bonded and non-bonded flexibles
- Stress concentration close to end fittings

PROJECT REFERENCES

- Stress and fatigue assessment of Thunderhorse water injection riser, BP
- Fatigue analysis of Agbami risers, Chevron
- Extreme stress evaluation of Veslefrikk B flexible jumpers, Equinor (Statoil)
- Fatigue analysis of Visund production riser, NOV (NKT Flexibles)
- Verification of full scale fatigue test, GE (Wellstream)
- Stress analysis of tensile and pressure armor wires, Technip
- Local buckling capacity of tensile armor wires, Technip

DEVELOPMENT

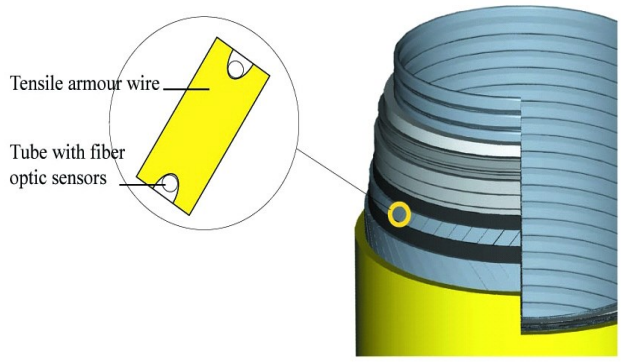
- 1990s – Fatigue on tensile armor wires, medium water depth
- 2000s – Fatigue on pressure armor wires, deep water
- 2010s – Anti-wear tape effects, compressive capacity, ultra deep water
- 2013 – Local buckling of tensile armor wires
- 2015 – Extended to bonded flexibles

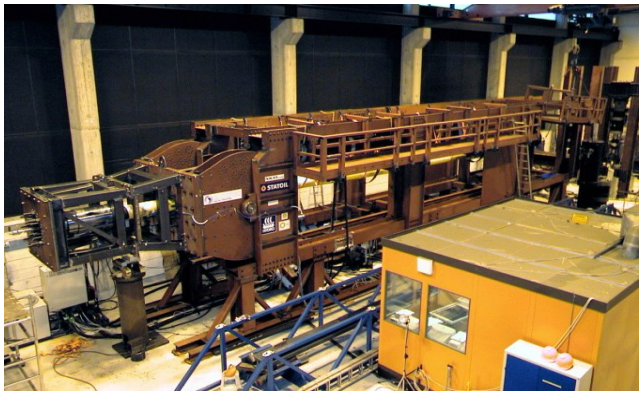
VERIFICATION

- 1990s – Physical properties including axial, torsional stiffness and non-linear moment curvature relation
- 2000s – Stress components, hysteresis effect due to friction
- 2010s – Axial compression capacity
- 2015 – Buckling of tensile armor wires

KEY PUBLICATIONS

- Sævik, S. (1993), A finite element model for predicting stresses and slip in flexible pipe armouring tendons. Computers & Structures, 46(2), p.219-230
- Sævik, S. (1999), A finite element model for predicting longitudinal stresses in non-bonded pipe pressure armours. Proc. of MARINFLEX'1999
- Sævik, S. (2011), Theoretical and experimental studies of stresses in flexible Pipes, Computers & Structures, 89(2 324):2, p.273-291
- Ye, N. and Sævik, S. (2011), Multi-axial fatigue of pressure armors in flexible risers, OMAE'2011-50210
- Ye, N., Sævik, S. and Zhou, C. (2014), Investigation of anti-wear tape's influence on bending behavior of one flexible riser, ISOPE'2014, TPC-1010
- Dai, Tianjiao; Sævik, Svein; Ye, Naiquan. (2017) Friction models for evaluating dynamic stresses in non-bonded flexible risers. Marine Structures. vol. 55.
- Dai, Tianjiao; Sævik, Svein; Ye, Naiquan. (2018) An anisotropic friction model in non-bonded flexible risers. Marine Structures. vol. 59.





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