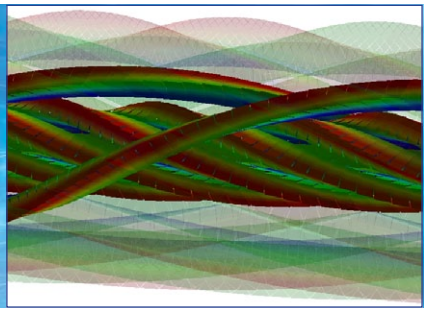
MARINTEK

UFLEX

Program System
Version 2.2 / 2010-01-12



SINTEF

Non-linear Stress Analysis of Complex Umbilical Cross-sections

Over more than 10 years, MARINTEK has been developing software tools for detailed analysis of the complex cross-sectional designs found in umbilicals and cables. The development of Uflex2d was initiated in close cooperation with Nexans Norway AS in the late 90's, and has taken advantage of MARINTEK's unique know-how in numerical methods and development of marine analysis tools with Nexans' wide-ranging experience of steel tube umbilical design. Small-scale and full-scale testing of components from a wide variety of umbilical designs are essential for calibration and verification purposes, and has been part of the work.

Figure 1. A typical umbilical cross-section, the Norne dynamic CSU (Control and Service Umbilical), installed in 1996.

With the ever-increasing water depths of new oil fields, new challenges are emerging, and the importance of taking into account 3D-effects increases. On this background a Joint Industry Project (JIP) was established to further continue the development of Uflex2d as well as to develop Uflex3d, which is a 3D-analysis tool for umbilicals. As part of the project two full scale test have been performed for verification of the numerical model. Axial- and bending-stress components for individual tubes in different layers were measured and compared with numerical results.

Test specimens of dynamic umbilical risers are typically cycled 2-3 million times in full-scale test rigs, such as MARINTEK's rig at the Marine Structures Laboratory in Trondheim, in order to verify fatigue performance under specified load conditions. The UFLEX Program System offers a way of improving umbilical design by enabling designers to study the effects of using different materials and varying cross-sectional geometry on a laptop computer, thus also limiting the necessity for expensive full-scale tests.

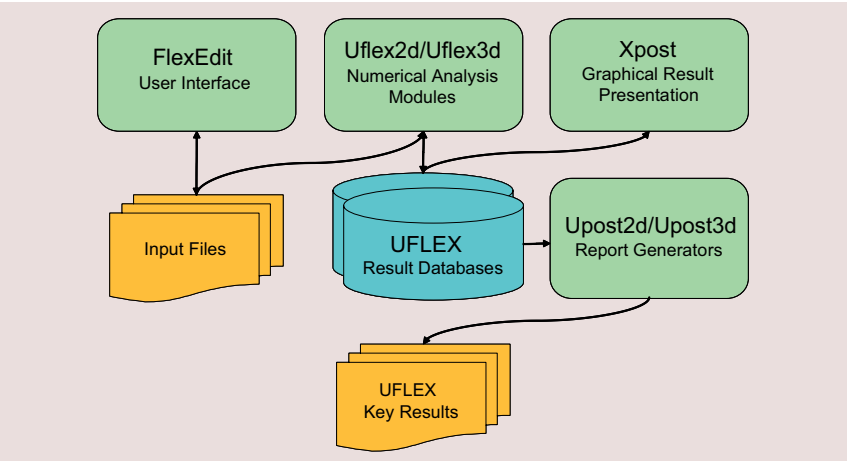


Figure 2. The UFLEX Program System - overview.

As shown in Figure 1 a dynamic umbilical is a very complex structure. In addition to having a sophisticated cross-section, each of the components of which the umbilical is built is helically wound in the longitudinal direction. This also implies that the development of a stress analysis tool for such cross-sections, taking into account both geometrical and material non-linearities, is quite a challenge.

System Overview

An overview of the UFLEX Program System is shown in Figure 2. The main components are:

- FlexEdit - User Interface

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- Uflex2d/Uflex3d - Numerical Analysis Modules
- Uflex Result Databases
- Xpost - Graphical Result Presentation
- Upost2d/Upost3d - Report Generators

FlexEdit forms a platform that can be used to connect the different modules of the UFLEX Program system. This tool is an intelligent editor giving easy access to the software documentation, as well as posibilities of launching directly the different software components inside the UFLEX program system.

Uflex2d and Uflex3d are the core of the system. All input to the analysis are based on files, hence making batch processing possible.

Xpost handles the visual display of the numerical model, and is also capable of exporting key results to file.

As an alternative to the GUI approach of Xpost, results can also be extracted through the report generators Upost2d and Upost3d.

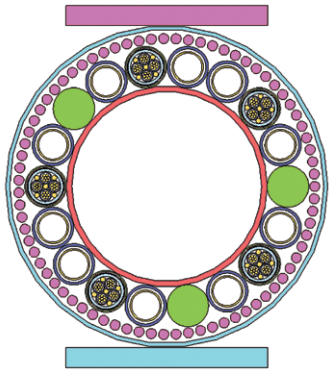

Figure 3. Uflex2d Model - global view.

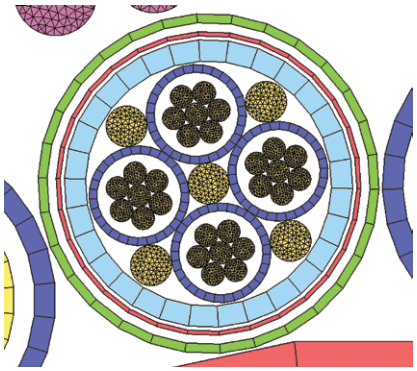

Figure 4. Uflex2d Model - zoomed in on a single copper conductor.

Analysis Functionality

The UFLEX Numerical Modules will include the following functionality:

- Arbitrary geometry modelling including helical elements wound into arbitrary order
- Elastic, hyperelastic and elasto-plastic material models
- Initial strain
- Contact elements, including friction
- Tension, torsion, internal pressure, external pressure, bending and external contact loading (caterpillars , tensioners)

Figures 3 and 4 show the Uflex2d geometry model and finite element mesh for a fourth-order umbilical cross-section.

Time Schedule

The current phase of the JIP is due to be completed by the end of 2012.

Financing

The UFLEX research and development project, including software development and full-scale testing for model verification, is being financed by the following group of sponsors: ABB, ExxonMobil, Chevron, Nexans, Oceaneering, Petrobras, Prysmian, SeaFlex, Statoil.

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