

Dynamic Stress Behaviour of Bonded Pipe and Umbilicals

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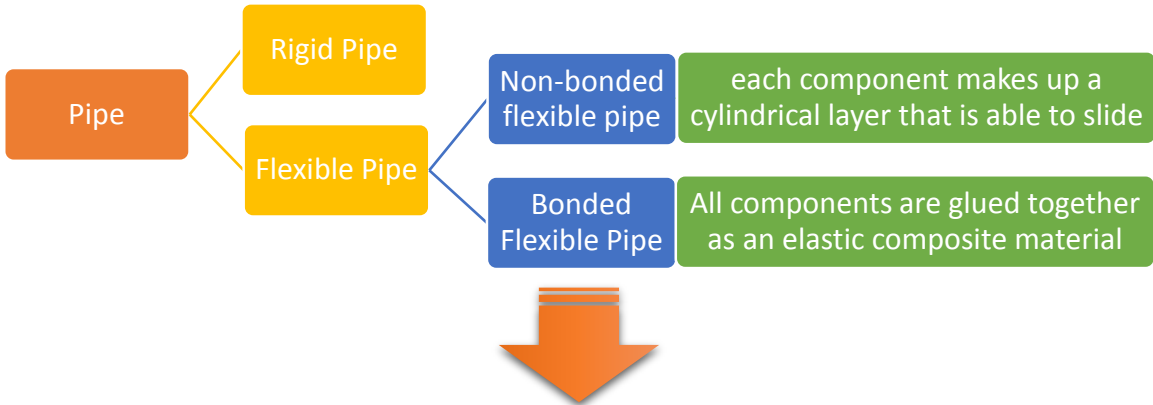


INTRODUCTION

Pipe is an essential part in the drill system. It could be used to transport fluid or gas subsea or topside, between different facilities and structures like from well to drilling platform, from platform to FPSO etc., used as:

Riser	• used to connect subsea installation with top side facilities to transport fluid
Flowline	• pipe transporting fluid over large distances
Jumper	• Short length of flexible pipe transporting fluid subsea or topside.

With the increasing consumption and high demand for transportation of subsea oil & gas, flexible pipe technology has successfully been applied during the recent years in connection with offshore production systems.

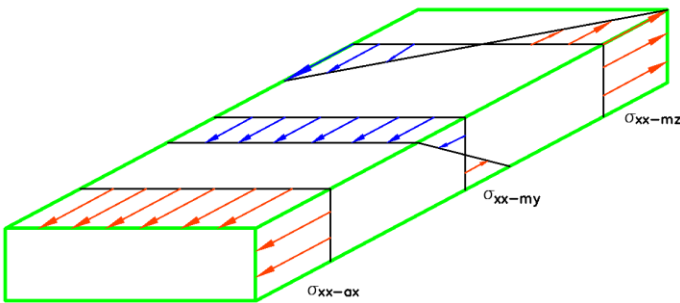


Key Facts of Bonded Flexible Pipes and Umbilicals

As opposed to non-bonded flexible pipes, loading hoses are normally made as a vulcanized structure where the armor tendons are embedded in rubber. In umbilicals, it is common procedure to protect the armor layers by application of bitumen which is a strongly temperature and loading rate dependent material. In both cases, the dynamic stresses due to bending will be governed by the shear deformations and mechanical properties of the surrounding material rather than the friction between the layers as for non-bonded pipes.

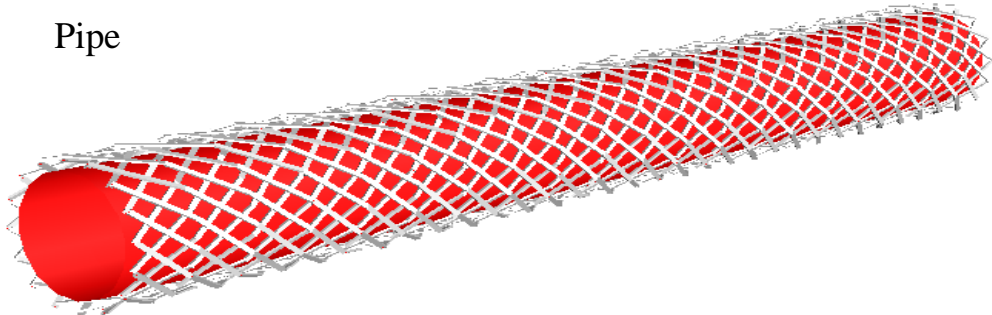
SCOPE OF WORK

1. Establish **Bflex models** for one **bonded hose**, one **bitumen protected umbilical**. For the bonded hose case, also establish a **non-bonded model** to be used as a reference
2. Perform stress analysis and **fatigue stress analysis** in Bflex using the above models and compare the results in terms of stress history plots showing the results from the different models in the same plot. The plots should include the stress illustrated in the figure below
 σ_{xx} : sum of below components
 σ_{xx-ax} : global axial stress
 σ_{xx-my} : global normal curvature stress
 σ_{xx-mz} : global transverse curvature stress

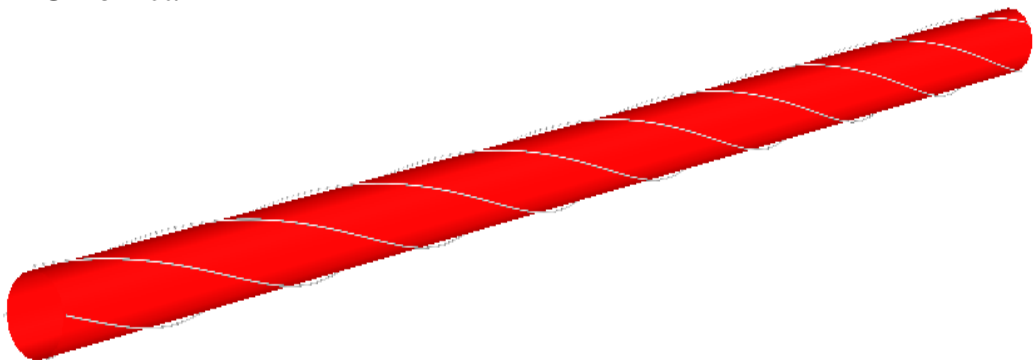


MODELLING

Pipe



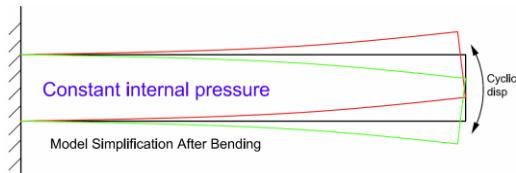
Umbilical



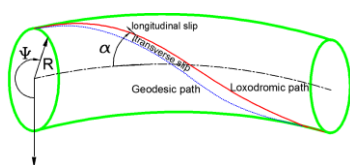
Technical data

Simplified model: all the layers except the tensile layers are integrated into one core pipe; two tensile layers, with rectangular circular shape helix tendons; Two contact layers made of polymeric material like rubber, with the elastic modulus about 26 MPa

Boundary condition:



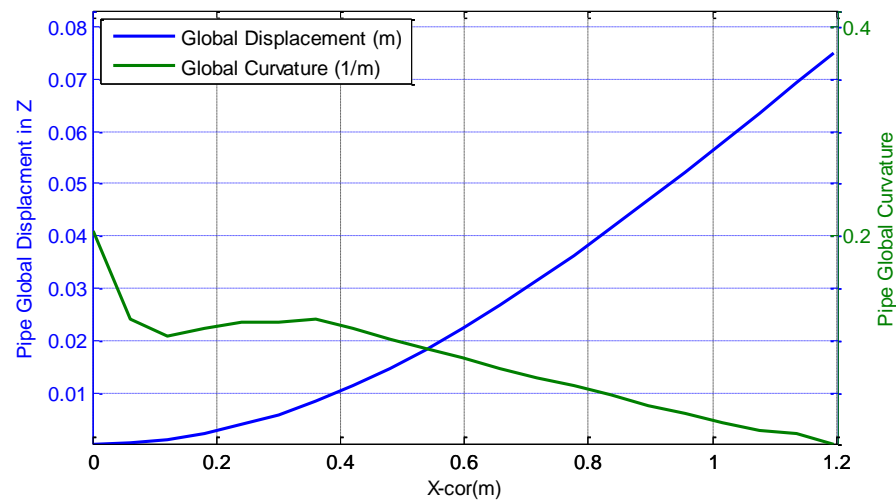
Loxodromic assumption:



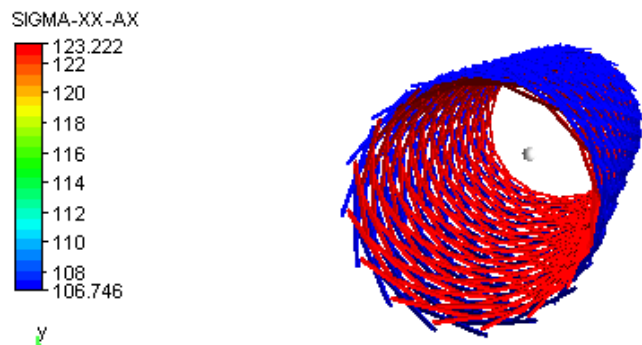
SIMULATIONS AND RESULTS

Displacement and deformation

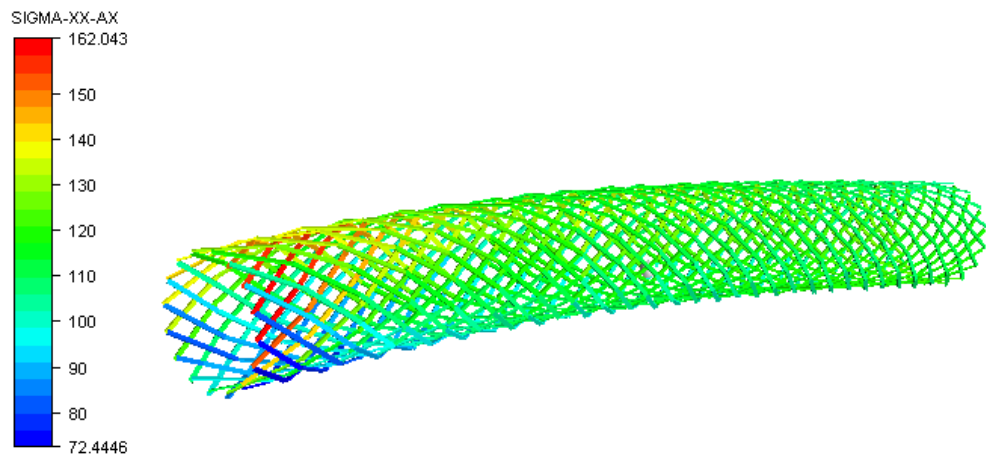
Global displacement and global curvature. Seeing that there is uncertainty around the stress concentration location of the pipe left end, to accurately measure the bending stiffness without the end effect, the measure point is selected at a distance the 0.48m to the left end



After the inner pressure is applied, the pipe has a elongation about 3.2%. Seen from the sigma-xx-ax plot, the inner tensile layer takes more pressure load.



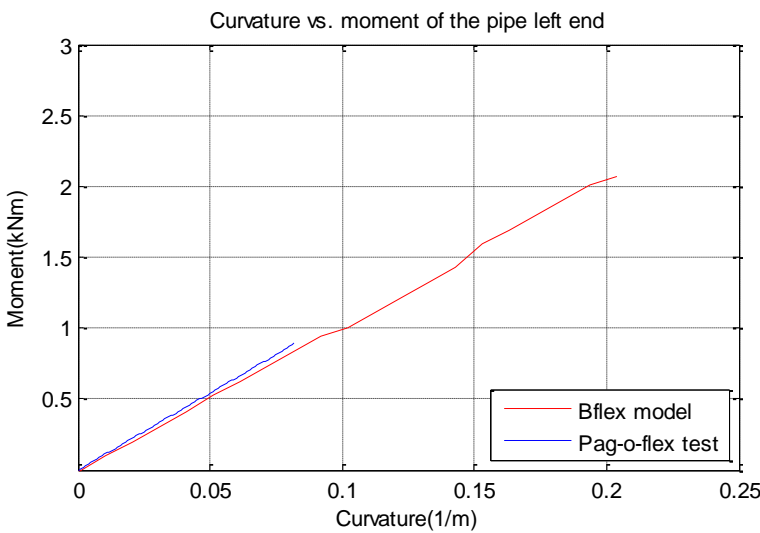
Axial Stress Distribution in Tendons



Bending stiffness

The bending stiffness is compared with the results from one test carried out at MARINTEK. This comparison between the bflex model and Pag-o-flex;s test is illustrated in the figure below.

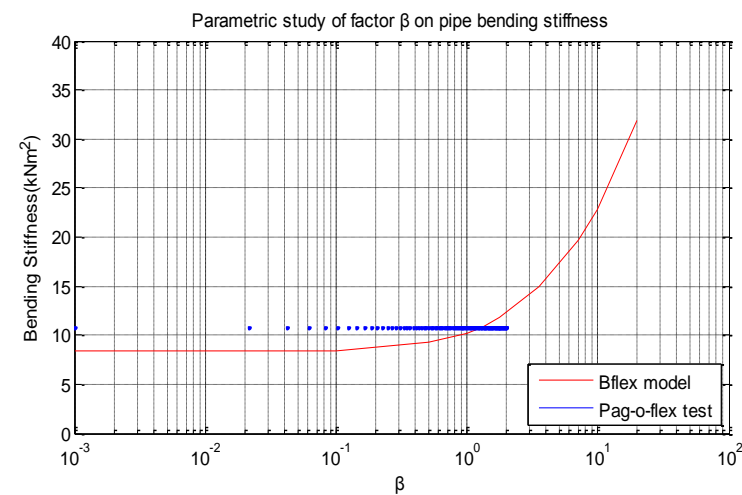
Bflex model bending stiffness = 10.1481 kNm². Experimental bending stiffness= 10.8537 kNm² The bending stiffness of the core pipe element is set to be 8.78 kNm². Thus, the contribution from the other elements is 1.3681 kNm².



Parametric Study of the Material Factor β

Normally the material of the contact layers between the tensile layers and other components varies a lot. This parametric study is too see how the material of the polymeric influence the bending stiffness of the structure.

It is seen that the asymptotic line goes to 8.8 kNm², which is the pre-defined bending stiffness of the core pipe. The bending stiffness has a sharp increase around the range of rubber type material from $\beta=1$ and higher. This demonstrates that the



Parametric Study of the Internal Pressure

From the Pag-o-flex result, it shows that the bending stiffness of the pipe would increase with the increase of the applied internal pressure load.

Thinking about the non-bonded pipe situation, the internal pressure puts more pressure load on the contact layers, leading to the increase of the friction between layers in contact, thus making the pipe stiffer. However, in my opinion, the mechanism for bonded pipe situation to have a higher value of bending stiffness under higher internal pressure load is not clear. This is the ongoing part and focus of the thesis.

