Flexible Pipe: Local Stress Analysis

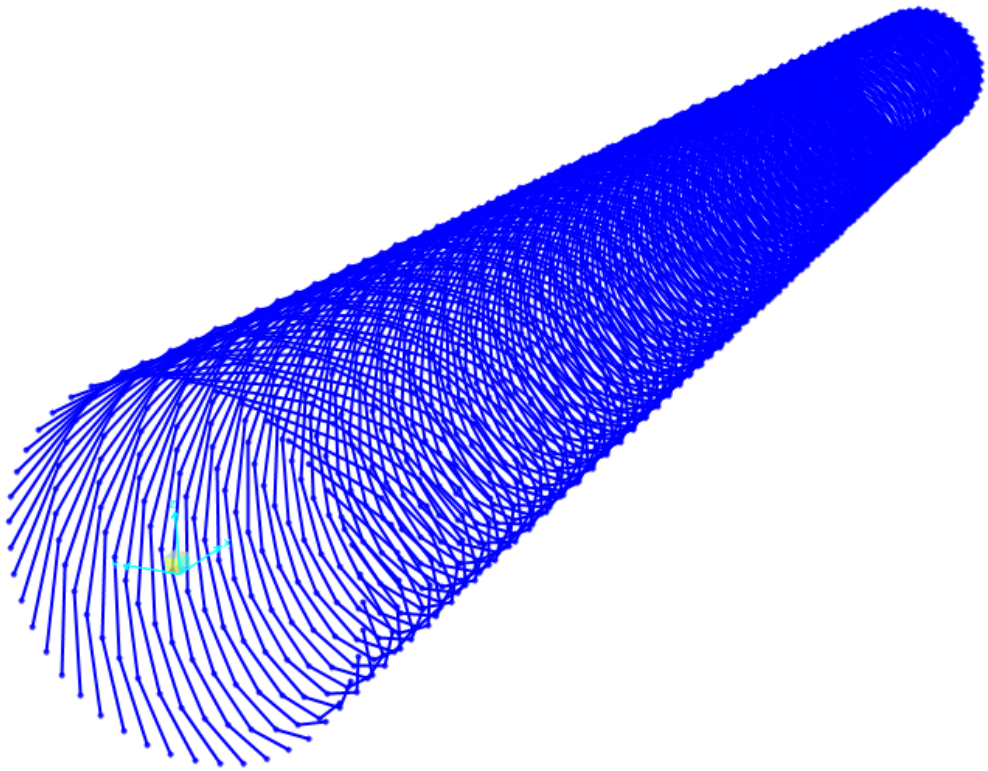

Figure 1 - Structural Model.

1- Introduction

The AAJL Engenharia LTDA is a company that develops specific structural models based on the Finite Element Method. Thus, the AAJL Engenharia LTDA intends to develop models according to the necessity of the clients. The mean cost of a project in Brazil is about R$ 150,00/h, including invoice issuance.

In this article the AAJL Engenharia presents a **simple example** of a Flexible Pipe subjected to the self weight and subjected to tension forces applied in each 44 wires. Thus, the AAJL Engenharia has performed a Local Stress Analysis of the Model.

2 - Input Data

Structure: Outer tensile armor of a 2.5 in Internal Diameter Flexible Pipe;

Number os wires: 44;

Lay angle: 35°;

Elements length: 2.98 cm;

Elements: 2,508;

Nodes: 2,552;

Total Riser Length: 2 m.

Outer Tensile Armor Diameter (m)	Density (kg/m^3)	Longitudinal Young's Modulus (GPa)	Yield Stress (MPa)
0.1045	7,800	205	1,260

3 - Static Non-Linear Analysis - Applied Self Weight and Tensile Force

- ✓ Type of Elements: 3D;
- ✓ Frame Elements.

Figure 2 - Numerical Configuration: Applied Self Weight and Axial Force.

4 - Restraints in Nodes

All nodes of side A (Figure 2), with X coordinates equal to zero are restrained at X, Y and Z direction; and in rotations about X, Y and Z. The others nodes are restrained only at Y and Z direction.

5 - Applied Forces

It was supposed a longitudinal force of 4,492.04 kN applied at Side B (Figure 2), as an operation load.

Thus, 4,492.04 kN divided per 44 wires, resulted in 102.09 kN applied in each wire.

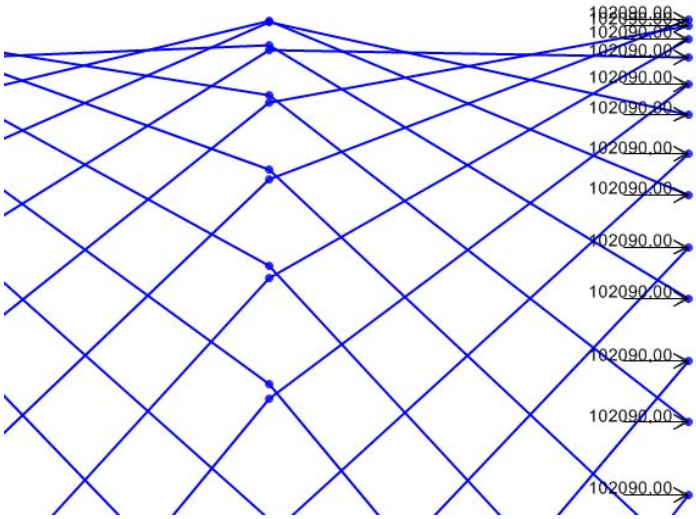

Figure 3 - Applied Axial Force.

6 - Results: Node 754 and Element 754

See Figure 2 to identify the node 754.

Displacement (m)	Axial Stress (MPa)
0.1254	9,100.63

7 - Allowable Stress for the Supposed Load Condition

Element	Maximum Stress (MPa)	Yield Stress (MPa)	Allowable Stress (MPa) - API 17J	Ratio
754	9,100.63	1,260	844.2[(1)]	10.78

Note 1: API 17J: Alowable Stress = UF x Yield Stress (UF = 0.67, for Normal Operation, Recurrent Operation).

12 - Conclusion

On section 7, it is observed that the maximum stress presented a value greater than the allowable stress. This means that for the condition proposed (longitudinal force of 4,492.04 kN), the 2.5 in Internal Diameter Flexible Pipe can not be applied, because the outer tensile armor would not resit the loads.
It is important to remember that the example is a simple model. To be realistc, it is required to execute global analysis of a real load condition. Furthermore, a Finite Element Model regarding the inner layers should implemented, including contact elements between layers, instead of simply restrain the displacements in Y and Z direction. Moreover, a test with a real flexible pipe sample is essential to validate the numerical model.

Aluizio de Amorim Pacheco
aluizio.pacheco@aajl-engineering.com

AAJL Engenharia LTDA
www.aajl-engineering.com