



## **Dyneema® 3T rope model for accurate mooring analysis with Deeplines Wind™** **- the key to improved accuracy and reduced risks -**

### Introduction:

A specific type of properties for Dyneema® DM20 ropes has been implemented into DEEPLINES. Input data provided by DSM are introduced as an external encrypted file (Dyneema® 3T rope model).

This file contains information which allows an automatic update of the Dyneema® rope dynamic stiffness and structural damping during a time domain simulation accounting for the temperature, the loading frequency and the average axial strain experienced by the rope.

To get access to this feature, you have to:

- Use DEEPLINES version V5R7 (contact: [deeplines@principia.fr](mailto:deeplines@principia.fr));
- On the DSM website a request can be submitted to obtain Dyneema® 3T rope model as an encrypted file.

[https://www.dsm.com/dyneema/en\\_GB/company-info/other-request.html](https://www.dsm.com/dyneema/en_GB/company-info/other-request.html)

### Model input data:

The mooring model is defined as a classical mooring pattern in DEEPLINES. A mooring line may be composed of segments of different types. Segments made of Dyneema® fiber ropes are given dedicated properties.

As illustrated below, Dyneema® fiber rope properties are associated with classical bar elements in DEEPLINES except that:

- Option Synthetic is checked.
- A specific input file is selected (encrypted file provided by DSM).

In addition to this encrypted file, users must define:

- The linear mass (kg/m),
- the so-called “static” axial stiffness (N): This reference stiffness value to be defined in accordance with DSM. Unless otherwise specified, the reference stiffness is the dynamic stiffness of the rope at 23°C, 1Hz and mean strain of 1%, i.e.  $EA_{dynamic} = AE_{ref,23^{\circ}C,1Hz,1\%}$ . A classical value of 65MBL is often considered. More accurate input to the reference stiffness can be obtained by DSM or with your rope or tendon producer of choice.
- the outer diameter and the hydrodynamic (or aerodynamic) coefficients to compute hydrodynamic (aerodynamic) loads,

Other data may be defined as options:

- the submerged weight in N/m,
- temperature and thermal properties,
- post-processing data.

**Edit segment types...** ✕

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**Mechanical properties**

Linear  Non linear  Synthetic  Constitutive law

Lineic mass  kg/m

Input data file

Static axial stiffness  N

Quasi-static axial stiffness  N

Dynamic axial stiffness  N

Automatic definition

Breaking load  N

Kr\_inf

ML\_lim

Coef\_kr  Reset Default

Submerged weight  N/m

The equivalent submerged weight corresponds to the flexible pipe WITH its internal fluid. Will be kept constant whatever the internal fluid density.

**Damping**

Coefficients aM+bK  Actual ks(alpha) + ks(beta)

Stiffness coefficient

Rayleigh :

By mechanism :

Beta Coefficient

Traction

Bending

Torsion

Mass coefficient

Alpha

**VIV**

Damping rate

Strakes efficiency

**Finite element model**

Binodal bar  Trinodal bar  Cable

**Hydrodynamic properties (MORISON coefficients)**

Normal drag

Normal inertia

Normal added mass

Axial drag

Axial inertia

Axial added mass

Hydrodynamic diameter  mm

**Aerodynamic coefficients**

Normal drag

Axial drag

**Stress post-processing**

Outside diameter  mm

Wall thickness  mm

Corrosion thickness allowance  mm

Young modulus  GPa

Poisson coefficient

Failure stress  MPa

SCF

SCF Axial

SCF Bending

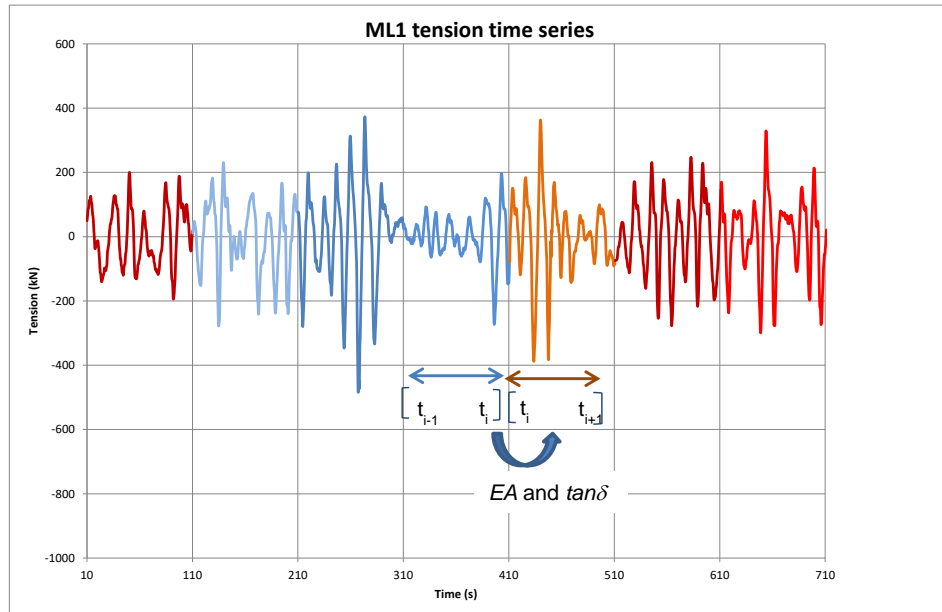
**Thermal properties**

Expansion coefficient  1/deg C

Reference T  deg C

Computation principles:

From a practical point of view, the simulation is split into time windows, which duration is to be fixed by the user, and results of a time window  $[t_{i-1}, t_i]$  are used to determine the dynamic stiffness and damping for the next sequence  $[t_i, t_{i+1}]$  as illustrated below.



Note: the sequence duration is to be defined by the user with a dedicated keyword.

Example:

\*SYNTHOPT

<i>loption_dyneema</i>	<i>Tstart</i>	<i>Tend</i>	<i>Twindow</i>
1	0	1000	200 0.

When computations start, the reference stiffness (static stiffness) is used. Then tensions and strains computed at all arc lengths of a line are stored during each sequence  $[t_i, t_{i+1}]$ .

At time step  $t_{i+1}$ , the dynamic stiffness and damping to be used for the next sequence  $[t_{i+1}, t_{i+2}]$  are evaluated as such:

- Get the zero up-crossing period  $T_z$  over  $[t_i, t_{i+1}]$  at each arc length along the line;
- Get the temperature  $T(^{\circ}\text{C})$  at  $t_{i+1}$  in case a variation in depth or in time is defined ;
- Get the average strain over  $[t_i, t_{i+1}]$  ;
- By convention,  $f=1/T_z$  is supposed to represent the average loading frequency;

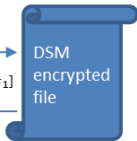
- Compute the updated axial stiffness as such :

$$EA = EA(T, f, \varepsilon)$$

Where  $EA(T, f, \varepsilon)$  is function derived from DSM input data

- Update the damping term considering a Rayleigh damping matrix  $C=aM+bK$ , with:  $a$  and derived from DSM input data
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- Use updated values for sequence  $[t_{i+1}, t_{i+2}]$

Sequence	Axial force $N_x$	Axial stiffness	Damping
Static / Quasi-static	Tension = $EA_s e_s$	$EA_s$	0
Sequence $[t_0, t_1]$	Tension(t) = $EA_s e_s + EA_{QS} (e_{QS} - e_s) + EA_t (e(t) - e_{QS})$	$EA_{t_0}$	$\tan(\delta_{t_0})$
Sequence $[t_1, t_2]$	Tension(t) = $EA_s e_s + EA_{QS} (e_{QS} - e_s) + EA_{t_0} (e_{t_0} - e_{QS}) + EA_{t_1} (e(t) - e_{t_0})$	$EA_{t_1}$	$\tan(\delta_{t_1})$



DSM encrypted file

$T_{temp}(t_1) \& \{f, \varepsilon\}_{average [t_0, t_1]}$