

Tether results comparison and debugging

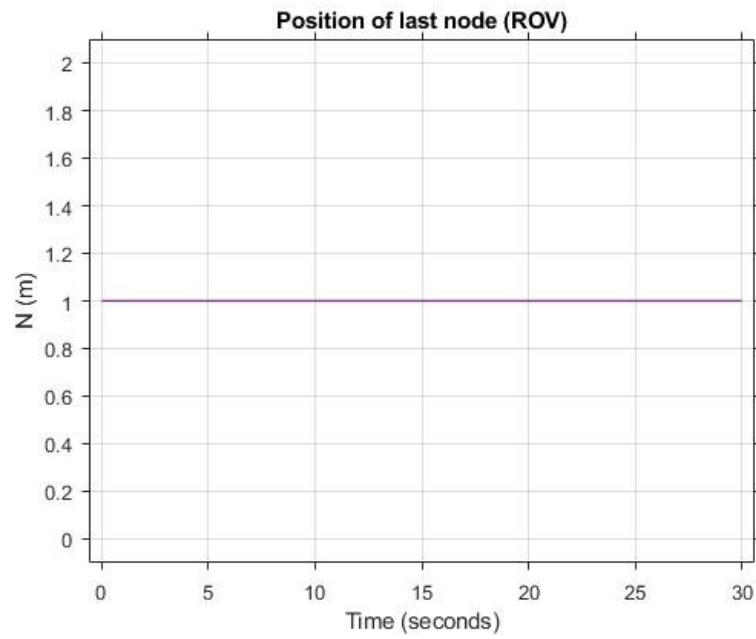


Fig1. Step Unit step input at $t=0$ s

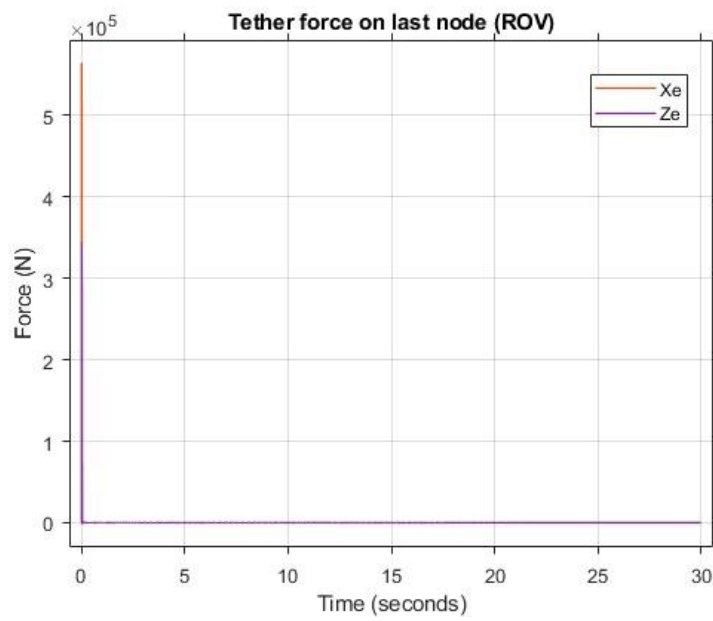


Fig2. Tether force results of benchmark model

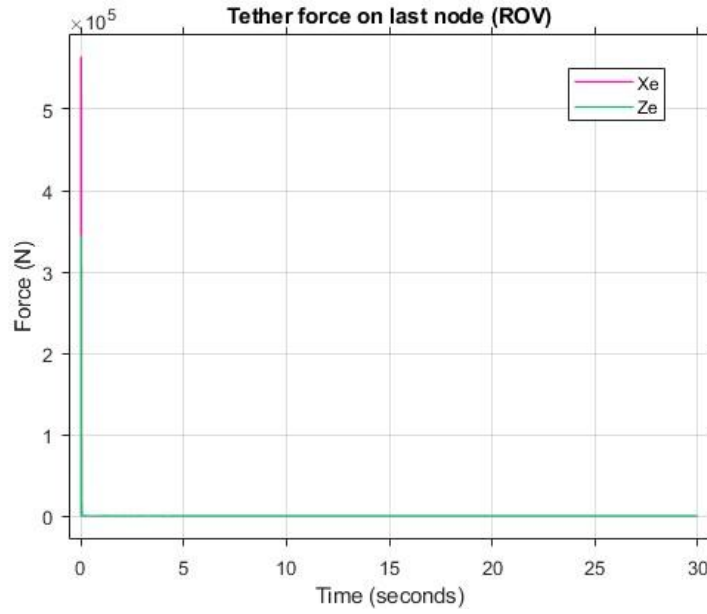


Fig2. Tether force results of my model

At $t = 1e - 04$ (The time at which the change in acceleration was observed)

The acceleration of 10th node

a) *Benchmark*

$$\dot{v}_i = \begin{bmatrix} 1.849777911961396 \\ 0 \\ 1.130686047143891 \end{bmatrix} \times 10^6$$

b) *My*

$$\dot{v}_i = \begin{bmatrix} 1.849777911961395 \\ 0 \\ 1.130686047143890 \end{bmatrix} \times 10^6$$

Difference between benchmark and my results in X direction is:- $9.313226e-10$

Difference between benchmark and my results in Y direction is:- $0.000000e+00$

Difference between benchmark and my results in Z direction is:- $9.313226e-10$

The velocity of 10th node

a) *Benchmark*

$$v_i = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

b) *My*

$$v_i = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

The position of 10th node

a) *Benchmark*

$$p_i = \begin{bmatrix} -2.680951323690902 \\ 0 \\ 22.75 \end{bmatrix}$$

b) *My*

$$p_i = \begin{bmatrix} -2.689051323690902 \\ 0 \\ 22.75 \end{bmatrix}$$

Difference between benchmark and my results in X direction is:- 0.000000e+00

Difference between benchmark and my results in Y direction is:- 0.000000e+00

Difference between benchmark and my results in Z direction is:- 0.000000e+00

Tension ($T_{i-1} - T_i$)

a) *Benchmark*

$$T_{bm} = \begin{bmatrix} -5.644139726536330e + 05 \\ 0 \\ -3.450008779788236e + 05 \end{bmatrix}$$

b) *My*

$$T_{bm} = \begin{bmatrix} -5.644139726536326e + 05 \\ 0 \\ -3.450008779788234e + 05 \end{bmatrix}$$

Difference between benchmark and my results in X direction is:- 3.492460e-10

Difference between benchmark and my results in Y direction is:- 0.000000e+00

Difference between benchmark and my results in Z direction is:- 2.328306e-10

Hydrodynamic force (F_i)

a) *Benchmark*

$$F_i = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

b) *My*

$$F_i = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

At $t = 1.2e - 04$ (The time at which the change in Hydrodynamic force was observed)

The acceleration of 10th node

a) *Benchmark*

$$\dot{v}_i = \begin{bmatrix} 1.762311212736936 \\ 0 \\ 1.098129265192919 \end{bmatrix} \times 10^6$$

b) *My*

$$\dot{v}_i = \begin{bmatrix} 1.762311212736935 \\ 0 \\ 1.098129265192918 \end{bmatrix} \times 10^6$$

Difference between benchmark and my results in X direction is:- 1.164153e-09

Difference between benchmark and my results in Y direction is:- 0.000000e+00

Difference between benchmark and my results in Z direction is:- 9.313226e-10

The velocity of 10th node

a) *Benchmark*

$$v_i = \begin{bmatrix} 36.995558239227911 \\ 0 \\ 22.613720942877823 \end{bmatrix}$$

b) *My*

$$v_i = \begin{bmatrix} 36.995558239227897 \\ 0 \\ 22.613720942877812 \end{bmatrix}$$

Difference between benchmark and my results in X direction is:- 1.164153e-09

Difference between benchmark and my results in Y direction is:- 0.000000e+00

Difference between benchmark and my results in Z direction is:- 9.313226e-10

The position of 10th node

a) *Benchmark*

$$p_i = \begin{bmatrix} -2.680951323690902 \\ 0 \\ 22.75 \end{bmatrix}$$

b) *My*

$$p_i = \begin{bmatrix} -2.689051323690902 \\ 0 \\ 22.75 \end{bmatrix}$$

Difference between benchmark and my results in X direction is:- 0.000000e+00
 Difference between benchmark and my results in Y direction is:- 0.000000e+00
 Difference between benchmark and my results in Z direction is:- 0.000000e+00

Tension ($T_{i-1} - T_i$)

a) *Benchmark*

$$T_{bm} = \begin{bmatrix} -5.644139726536330e + 05 \\ 0 \\ -3.450008779788236e + 05 \end{bmatrix}$$

b) *My*

$$T_{my} = \begin{bmatrix} -5.644139726536326e + 05 \\ 0 \\ -3.450008779788234e + 05 \end{bmatrix}$$

Difference between benchmark and my results in X direction is:- 3.492460e-10
 Difference between benchmark and my results in Y direction is:- 0.000000e+00
 Difference between benchmark and my results in Z direction is:- 2.328306e-10

Hydrodynamic force (F_i)

a) *Benchmark*

$$F_i = \begin{bmatrix} 2.668829964124261 \\ 0 \\ 0.9933896668861222 \end{bmatrix} \times 10^4$$

b) *My*

$$F_i = \begin{bmatrix} 2.668829964124259 \\ 0 \\ 0.993389666886121 \end{bmatrix} \times 10^4$$

Difference between benchmark and my results in X direction is:- 2.182787e-11
 Difference between benchmark and my results in Y direction is:- 0.000000e+00
 Difference between benchmark and my results in Z direction is:- 1.091394e-11

Another thing observed is that:

For tension the stiffness term is defined as $K = \frac{\left(E \times \left(\frac{\pi}{4}\right) \times d^2\right)}{l_0}$ in the paper

However, symbolically generated function simplifies this term and makes it

$K = E \times d^2 \times \left(\frac{1}{l}\right) \times \pi \times \left(\frac{5}{2}\right)$, but I used the above formula as it is and this gives different value of K

$$K_{bm} = 8.125084250018639e + 05$$

$$K_{my} = 8.125084250018637e + 05$$

After altering the formula of K and keeping it consistent with the benchmark one the results are as follows:

$$K_{bm} = 8.125084250018639e + 05$$

$$K_{my} = 8.125084250018639e + 05$$

However, still the value of tension is not equal and to further debug it I isolated the components of formula and check individual components for any existing difference.

Formula of tension is:

$$T_i = K \times (r_i - r_{i+1}) \times \left(\frac{l \times \left(\frac{1}{||r_i - r_{i+1}||} \right)}{10} - 1 \right)$$

Firstly, the comparison of K was done,

$$K_{bm} = 8.125084250018639e + 05$$

$$K_{my} = 8.125084250018639e + 05$$

Secondly, comparison of length of last segment was done,

$$(r_i - r_{i+1})_{bm} = \begin{bmatrix} -3.680951323690902 \\ 0 \\ -2.25 \end{bmatrix} \quad (r_i - r_{i+1})_{my} = \begin{bmatrix} -3.680951323690902 \\ 0 \\ -2.25 \end{bmatrix}$$

Lastly, the comparison of strain was done,

$$\left(\frac{l \times \left(\frac{1}{||r_i - r_{i+1}||} \right)}{10} - 1 \right)_{bm} = -0.188716472134787 \quad \left(\frac{l \times \left(\frac{1}{||r_i - r_{i+1}||} \right)}{10} - 1 \right)_{my} = -0.188716472134787$$

$$T_{bm} = \begin{bmatrix} -5.644139726536330e + 05 \\ 0 \\ -3.450008779788236e + 05 \end{bmatrix}$$

$$T_{my} = \begin{bmatrix} -5.644139726536327e + 05 \\ 0 \\ -3.450008779788234e + 05 \end{bmatrix}$$

Therefore, it can be seen that despite of similar values of all the components of tension formula there is difference in the value of tension.

