Tether results comparison and debugging

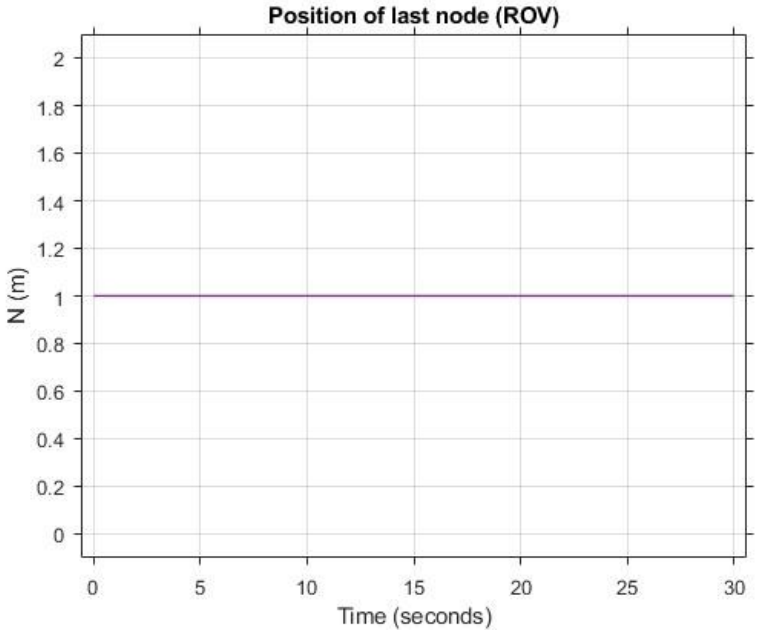

Fig1. Step Unit step input at t=0 s

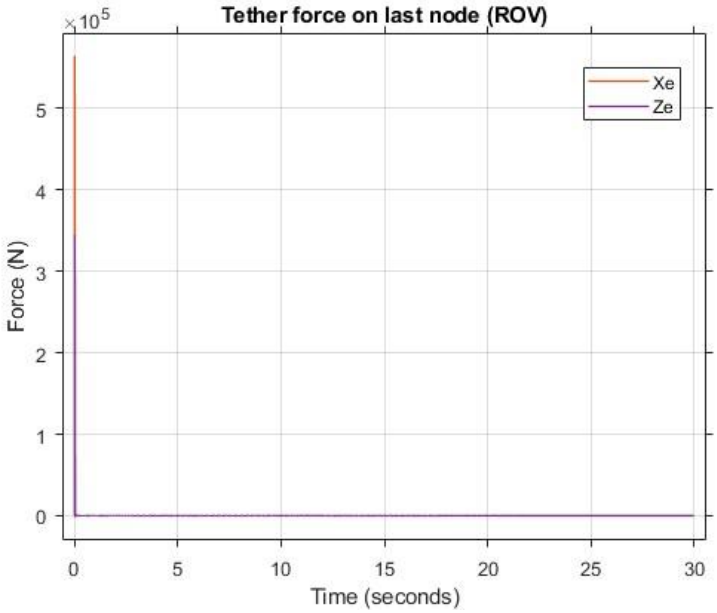

Fig2. Tether force results of benchmark model

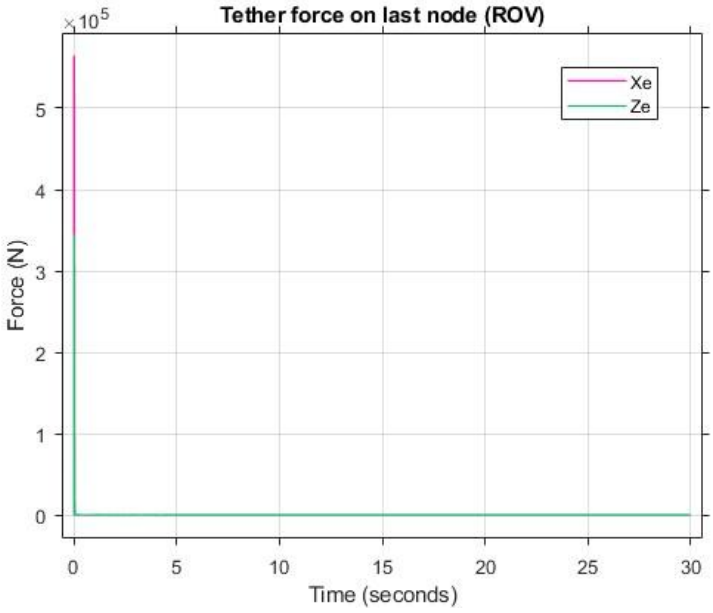

Fig2. Tether force results of my model

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*

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

b) *My*

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

```
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*

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

b) *My*

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

```
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*

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

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 $K = \dfrac{\left(E \times \left(\dfrac{\pi}{4}\right) \times d^2\right)}{l_0}$ **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

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

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