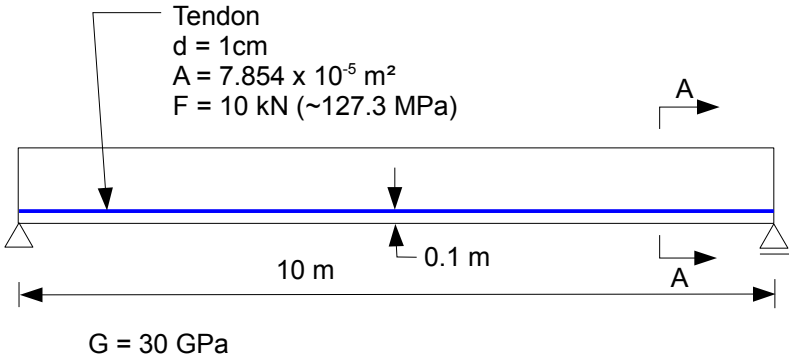
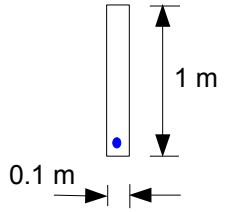
Modeling of Joint Opening in Segmental Bridge – Illustration of the Concept

Geometry



Beam Elevation



Section A-A
(Scale: 2x Elevation Scale)

Midspan moment due to tendon loading:

$$M = F\,r$$

Midspan moment due to uniform loading:

$$M = \frac{w L^2}{8}$$

Determine w to achieve zero mispan moment:

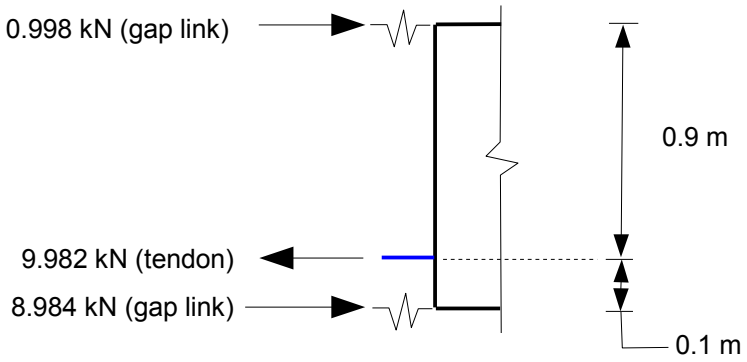
$$F\,r = \frac{w L^2}{8}$$

$$w = \frac{8 F\,r}{L^2} = \frac{8 \times 10\,kN \times 0.4\text{m}}{(10\,m)^2} = 0.32\,kN/m$$

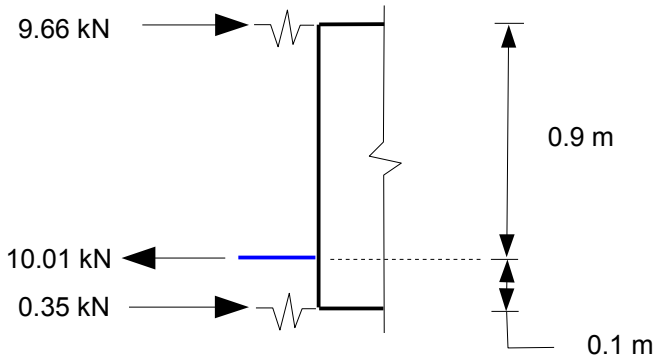
Comments:

(1) The beam will be modeled by 10 shell elements (9 shells 0.99m by 1m and 1 shell 1m by 1m) connected by gap links.

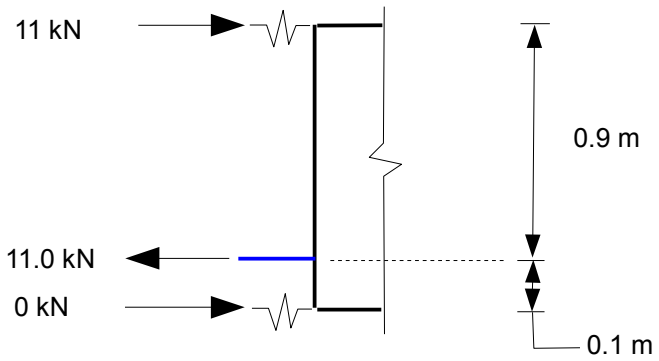
Midspan Joint Forces at Various Stages



Forces at the end of prestressing

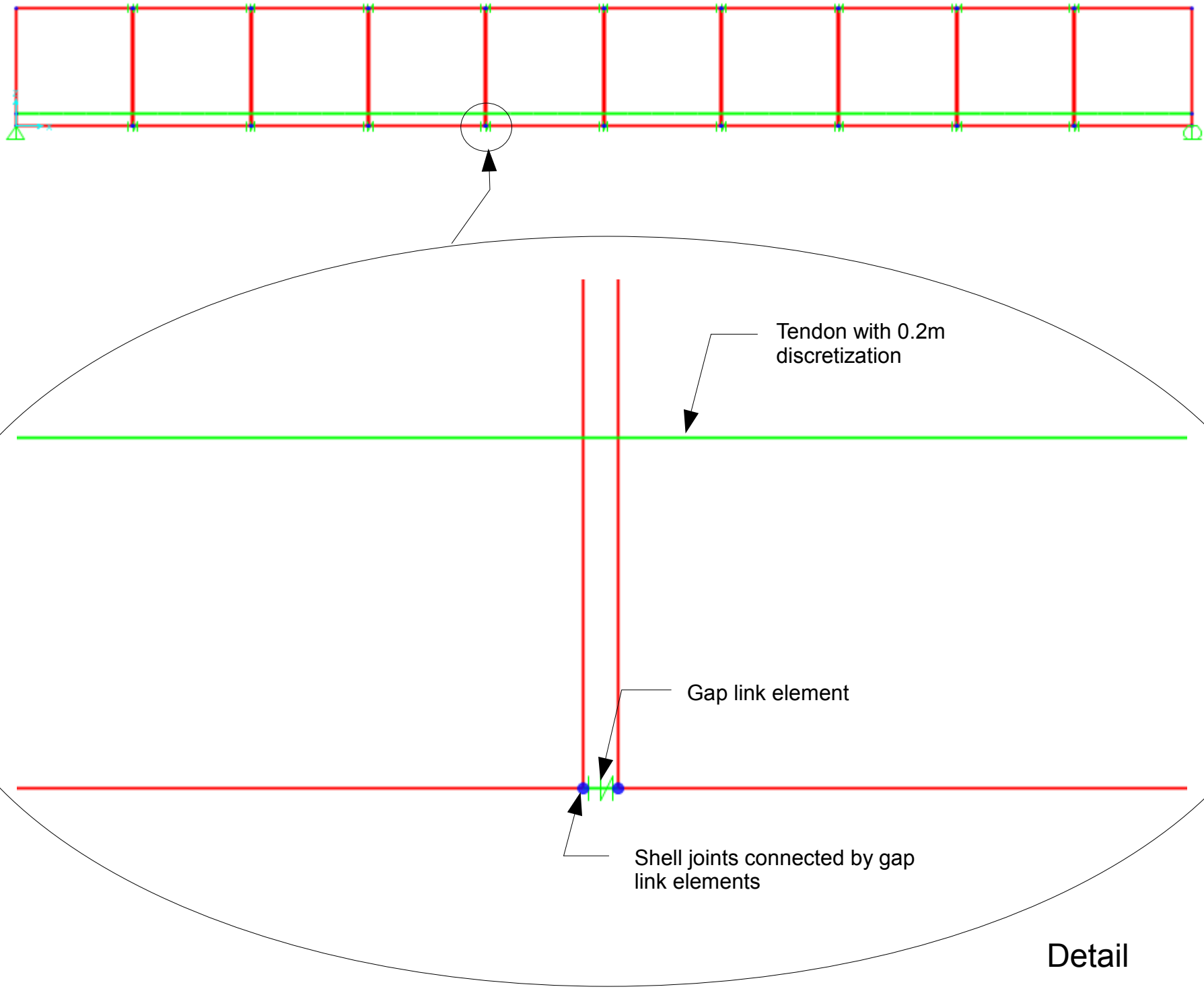


Forces just before the gap opening
(step 7 of „UNIT AFTER PS“ load case)



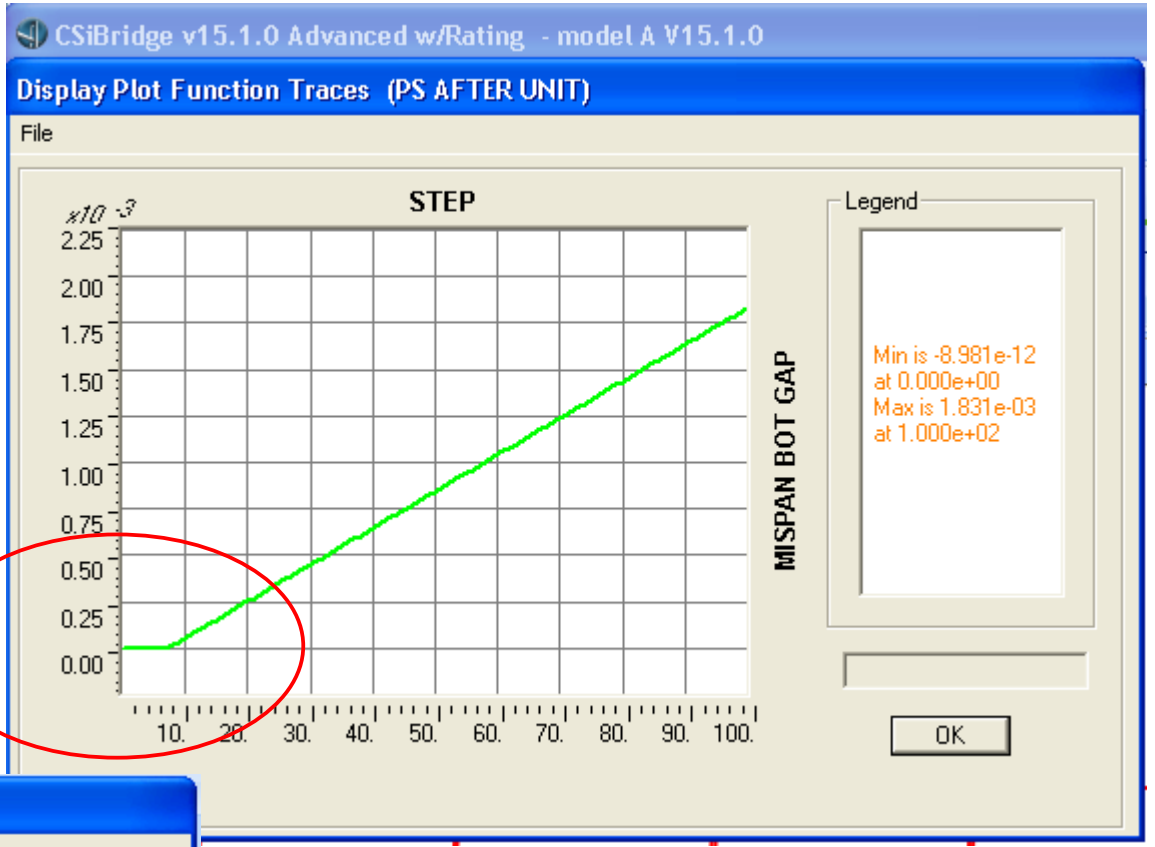
Forces just after the gap opening
(step 8 of the „UNIT AFTER PS“ load case)

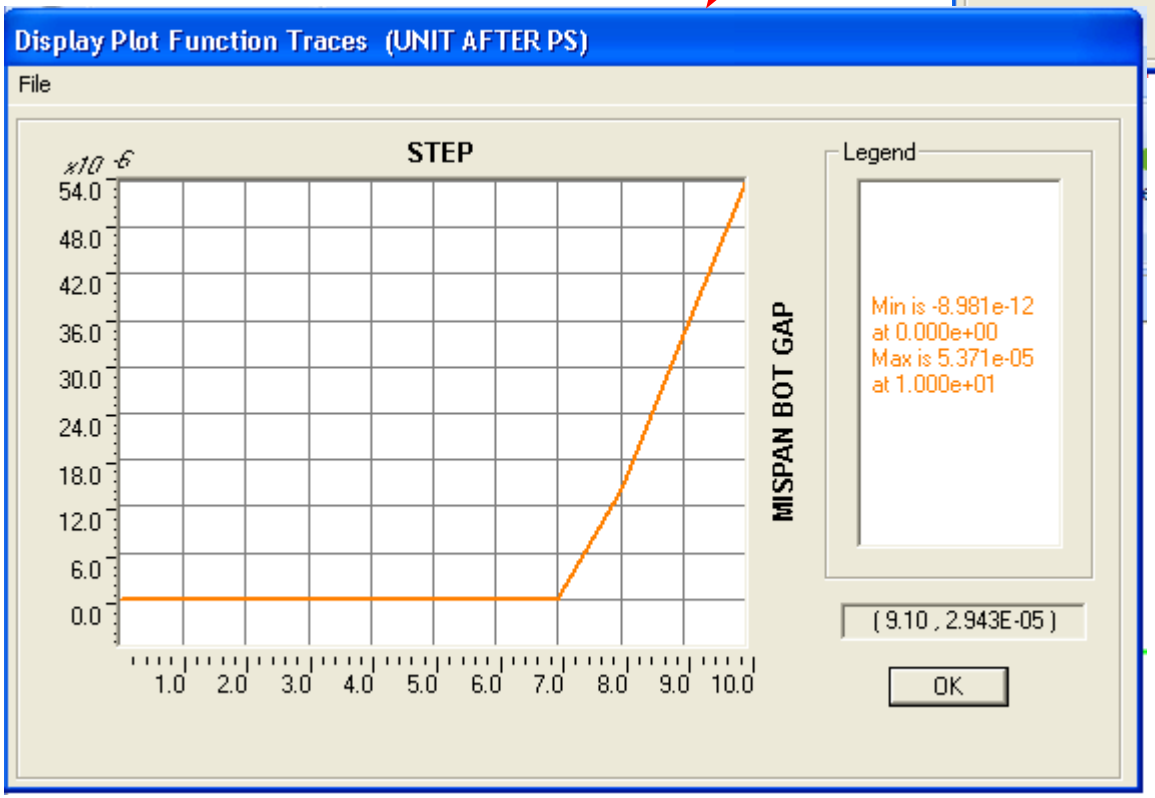
Model Screenshots


Tendon with 0.2m discretization
Gap link element
Shell joints connected by gap link elements
Detail

Midspan Gap Opening

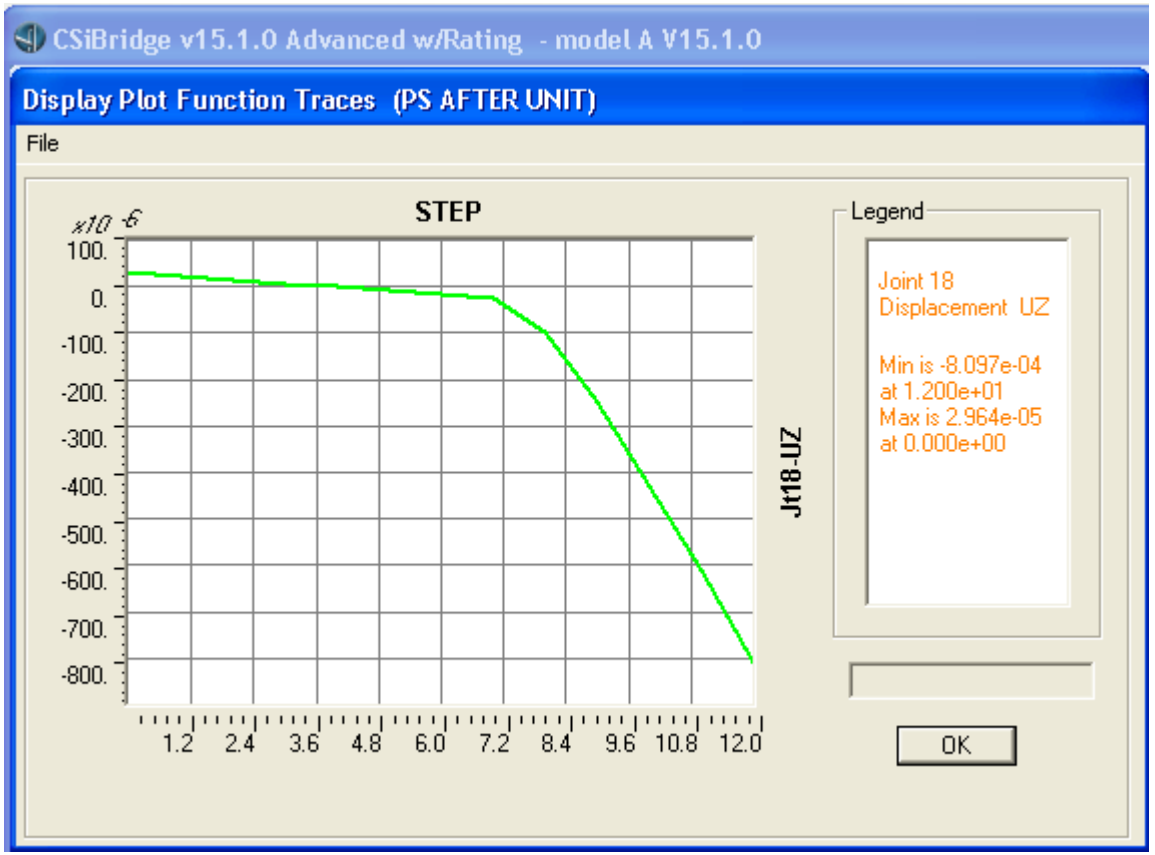
The joint starts opening when the compression stress due prestressing has been eliminated by tensile stresses due to the uniform loading in gravity direction.



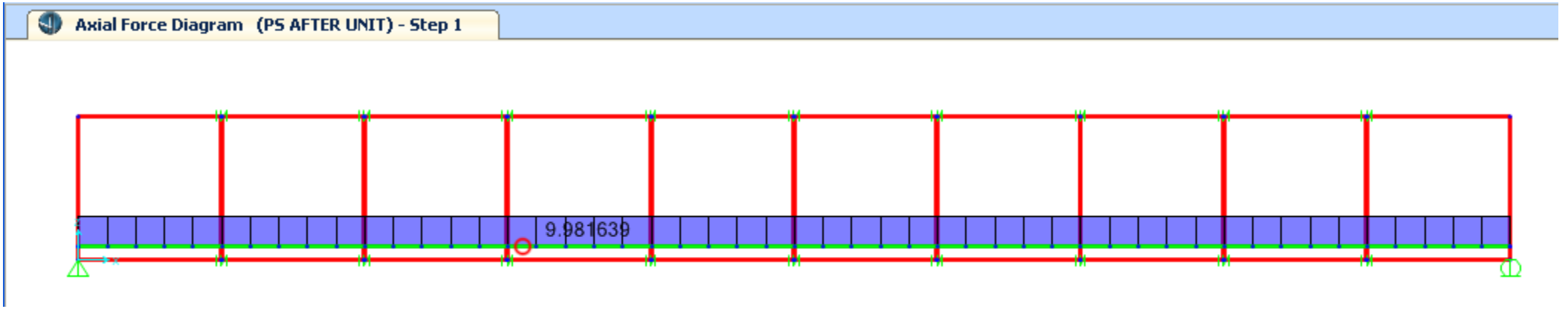


Midspan Deflection

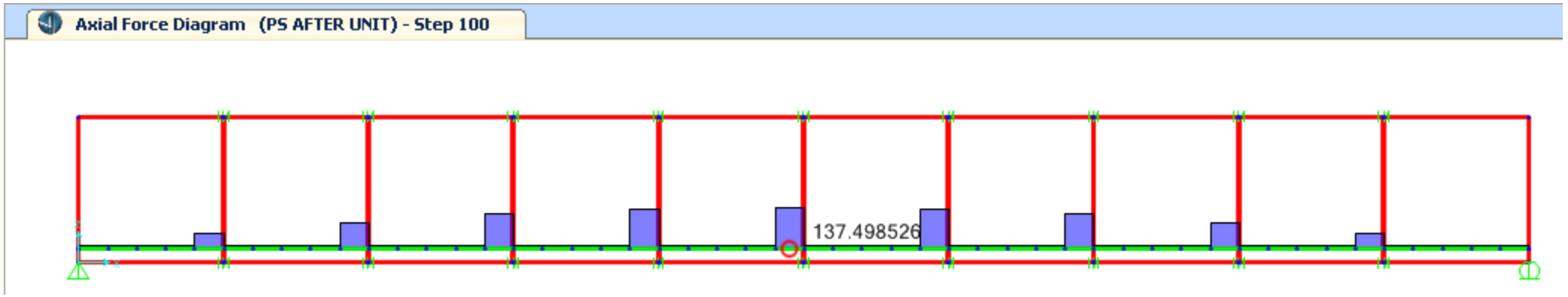
The plot of step vs. midspan deflection indicates that the structure softens are more joints open.



Tendon axial forces just after the prestress is applied:



Tendon axial forces after vertical load is applied and gaps open (note that tendon force increases over the gap as expected):



Summary

- This example illustrated the concept of modeling joint openings between segments.
- To obtain more realistic results, the discretization should be refined and larger number of gap link elements along the height of the section should be used.
- This approach can be used to model other behaviors, including compression only soil, etc.