nelmt25 Notes  
3D Pipe Element with Moderately Large Displacements

started Jan 2014 when generalized for 3D

# Formulation Notes

Axial strain ϵ = a – A  
a = x’ + y’2/2 + z’2/2, A = X’ + Y’2/2 + Z’2/2  
x=X+u, y=Y+v, z=Z+w  
⇒ ϵ = u’ + Y’ v’ + v’2/2 + Z’ w’ + w’2/2 = u’ + (Y’ + v’/2) v’ + (Z’ + w’/2) w’  
δϵ = δu’ + y’ δv’ + z’ δz’

Curvatures:  
κy = θy’, κz = θz’

Shears:  
γy = v’ + θy  
γz = w’ + θz

B-matrix:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | element node 1 | | | | | element node 2 | | | | |
|  | u | v | w | θy | θz | u | v | w | θy | θz |
| ϵ | -1/L | -y’/L | -z’/L |  |  | 1/L | y’/L | z’/L |  |  |
| κy |  |  |  | -1/L |  |  |  |  | 1/L |  |
| κz |  |  |  |  | -1/L |  |  |  |  | 1/L |
| γy |  | -1/L |  | ½ |  |  | 1/L |  | ½ |  |
| γz |  |  | -1/L |  | ½ |  |  | 1/L |  | ½ |
|  |  |  |  |  |  |  |  |  |  |  |
| L(DB)i | -Di1 | -Di1y’ -Di4 | -Di1 z’ -Di5 | -Di2 +Di4L/2 | -Di3 +Di5L/2 | Di1 | Di1y’ +Di4 | Di1 z’ +Di5 | +Di2 +Di4L/2 | +Di3 +Di5L/2 |
| L(DB)i | -c1 | -c2 | -c3 | -Di2+c4 | -Di3+c5 | c1 | c2 | c3 | Di2+c4 | Di3+c5 |
| (DB)i | -a1 | -a2 | -a3 | -a4+a6 | -a5+a7 | a1 | a2 | a3 | a4+a6 | a5+a7 |
| ELP | N | Ny’+Qy | Nz’+Qz | My -LQ­y/2 | Mz -LQz/2 | -N | -Ny’-Qy | -Nz’-Qz | -My -LQ­y/2 | -Mz -LQz/2 |

where c1=Di1, c2 = +Di1y’ +Di4 , c3= Di1 z’ + Di5 , c4 = Di4 L/2, c5 = Di5 L/2.

a1=Di1/L, a2=(y’Di1+Di4)/L, a3=(z’Di1+Di5)/L, a4=Di2/L, a5=Di3/L, a6=Di4/2, au=Di5/2

Nomenclature for elements of B-matrix:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | element node 1 | | | | | element node 2 | | | | |
|  | u | v | w | θy | θz | u | v | w | θy | θz |
| ϵ | -tst1 | -tst2 | -tst3 |  |  | tst1 | tst2 | tst3 |  |  |
| κy |  |  |  | -tst4 |  |  |  |  | tst4 |  |
| κz |  |  |  |  | -tst5 |  |  |  |  | tst5 |
| γy |  |  |  |  |  |  |  |  |  |  |
| γz |  |  |  |  |  |  |  |  |  |  |

# Improvements to be made

* NINTPT prompt for 3D case