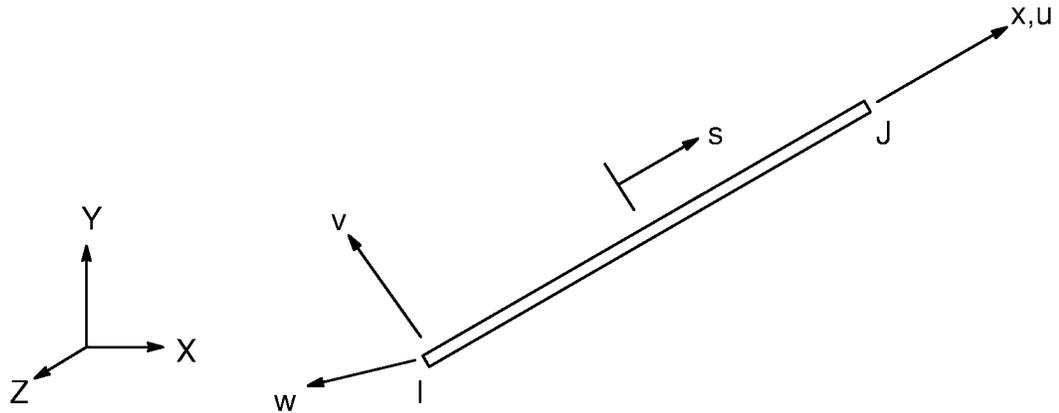


14.10 LINK10 — Tension Only or Compression-only Spar



Matrix or Vector	Shape Functions	Integration Points
Stiffness Matrix	Equation (12.2.1-1)	None
Mass Matrix	Equations (12.2.1-1), (12.2.1-2), and (12.2.1-3)	None
Stress Stiffness Matrix	Equations (12.2.1-2) and (12.2.1-3)	None
Thermal Load	Equation (12.2.1-1)	None

Load Type	Distribution
Element Temperature	Linear along length
Nodal Temperature	Linear along length

14.10.1 Assumptions and Restrictions

The element is not capable of carrying bending loads. The stress is assumed to be uniform over the entire element.

14.10.2 Element Matrices and Load Vector

All element matrices and load vectors are generated in the element coordinate system and must subsequently then be converted to the global coordinate system. The element stiffness matrix is:

$$[K_\ell] = \frac{AE}{L} \begin{bmatrix} C_1 & 0 & 0 & -C_1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ -C_1 & 0 & 0 & C_1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \quad (14.10-1)$$

where:

- A = element cross-sectional area (input as AREA on **R** command)
- E = Young's modulus (input as EX on **MP** command)
- L = element length
- C₁ = value given in Table 14.10-1

Table 14.10-1 Value of Stiffness Coefficient (C₁)

User Options	Strain is Currently Tensile	Strain is Currently Compressive
KEYOPT(2) = 0 KEYOPT(3) = 0	1.0	0.0
KEYOPT(2) > 0 KEYOPT(3) = 0	1.0	1.0 x 10 ⁻⁶
KEYOPT(2) = 0 KEYOPT(3) = 1	0.0	1.0
KEYOPT(2) > 0 KEYOPT(3) = 1	1.0 x 10 ⁻⁶	1.0

Meanings:

KEYOPT(2) = 0	No extra stiffness for non-load carrying case
KEYOPT(2) = 1,2	Has small stiffness for non-load carrying case
KEYOPT(3) = 0	Tension-only spar
KEYOPT(3) = 1	Compression-only spar

The element mass matrix is the same as for LINK8 (Section 14.8):

The element stress stiffness matrix is:

$$[S_\ell] = \frac{F}{L} \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & C_2 & 0 & 0 & -C_2 & 0 \\ 0 & 0 & C_2 & 0 & 0 & -C_2 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -C_2 & 0 & 0 & C_2 & 0 \\ 0 & 0 & -C_2 & 0 & 0 & C_2 \end{bmatrix} \quad (14.10-2)$$

where:

$$F = \begin{cases} \text{for the first iteration: } A E \varepsilon^{in} \\ \text{for all subsequent iterations: the axial force} \\ \text{in the element (output quantity FORC)} \end{cases}$$

$C_2 =$ value given in Table 14.10-2.

Table 14.10–2 Value of Stress Stiffness Coefficient (C₂)

User Options	Strain is Currently Tensile	Strain is Currently Compressive
KEYOPT(2) < 2 KEYOPT(3) = 0	1.0	0.0
KEYOPT(2) = 2 KEYOPT(3) = 0	1.0	$\frac{AE}{F 10^6}$
KEYOPT(2) < 2 KEYOPT(3) = 1	0.0	1.0
KEYOPT(2) = 2 KEYOPT(3) = 1	$\frac{AE}{F 10^6}$	1.0

Meanings:

KEYOPT(2) = 0,1	No extra stress stiffness value
KEYOPT(2) = 2	Include extra stress stiffness value
KEYOPT(3) = 0	Tension-only spar
KEYOPT(3) = 1	Compression-only spar

The element applied load vector is:

$$\{F_\ell\} = AE\epsilon^T \begin{bmatrix} -C_1 & 0 & 0 & C_1 & 0 & 0 \end{bmatrix}^T \quad (14.10-3)$$

where:	ϵ^T	=	$\alpha\Delta T - \epsilon^{in}$
	α	=	coefficient of thermal expansion (input as ALPX on MP command)
	ΔT	=	$T_{ave} - T_{REF}$
	T_{ave}	=	average temperature of element
	T_{REF}	=	reference temperature (input on TREF command)
	ϵ^{in}	=	prestrain (input as ISTRN on R command)