Program:	RFEM 5, RSTAB 8

| Category:	Geometrically Linear Analysis, Isotropic Linear Elasticity, Temperature Dependency, Member

Verification Example:	0077 – Gap-Filling Thermal Expansion

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Description

A steel rod between two rigid supports with a gap is loaded by a temperature difference T_c according to **Figure 1**. While neglecting self-weight, determine the total deformation u_x of the rod and its internal axial force N.

Material	Steel	Modulus of Elasticity	E	210000.000	MPa
		Poisson's Ratio	ν	0.300	—
		Coefficient of Thermal Expansion	α	1.200×10^{-5}	°C⁻¹
Geometry		Cross-section Width	a	10.000	mm
		Length	L	300.000	mm
		Gap	δ	0.100	mm
Load		Thermal Loading	T_c	100.0	°C
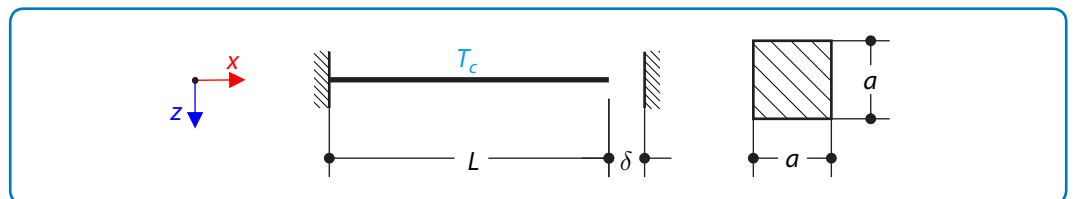
Figure 1: Problem Sketch

Analytical Solution

Thermal expansion ΔL of the bar is generally expressed by

$$\Delta L = \alpha L \Delta T \qquad (77-1)$$

Using this formula, the sought temperature difference for filling the gap δ can be calculated.

$$\Delta T = \frac{\delta}{\alpha L} \approx 27.8 \,°C \qquad (77-2)$$

Note that the given temperature difference T_c is greater than the temperature difference ΔT, hence the bar is then loaded by an axial force, because it cannot expand any further. The internal

axial force N can be calculated using the global condition for the deformation, namely, the total deflection of the rod (due to the temperature and axial force) has to be zero, $\Delta L_T + \Delta L_N = 0$,

$$\alpha L(T_c - \Delta T) + \frac{NL}{EA} = 0 \quad \Rightarrow \quad N = -\alpha EA(T_c - \Delta T) \approx -18.200 \text{ kN} \qquad (77-3)$$

RFEM 5 and RSTAB 8 Settings

- Modeled in RFEM 5.16.01 and RSTAB 8.16.01
- The element size is $l_{FE} = 0.050$ m
- Isotropic linear elastic model is used
- Nodal Support with Stop Diagram in x-direction is used, see **Figure 2**
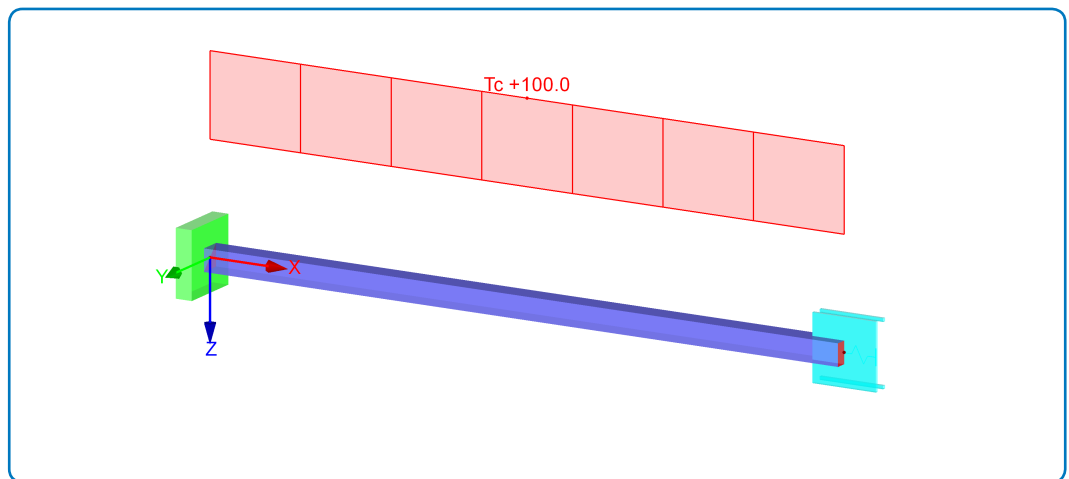
Figure 2: Model in RFEM 5 / RSTAB 8

Results

Structure Files	Program	Entity
0077.01	RFEM 5	Member
0077.02	RSTAB 8	Member

Quantity	Analytical Solution	RFEM 5	Ratio	RSTAB 8	Ratio
u_x [mm]	0.100	0.100	1.000	0.100	1.000
N [kN]	-18.200	-18.200	1.000	-18.200	1.000