Program: RFEM 5

Category: NAFEMS Benchmark, Large Deformation Analysis, Post-Critical Analysis, Isotropic Linear Elasticity, Dynamics, Member

Verification Example: NAFEMS NL 7 – Lee´s Frame Buckling Problem
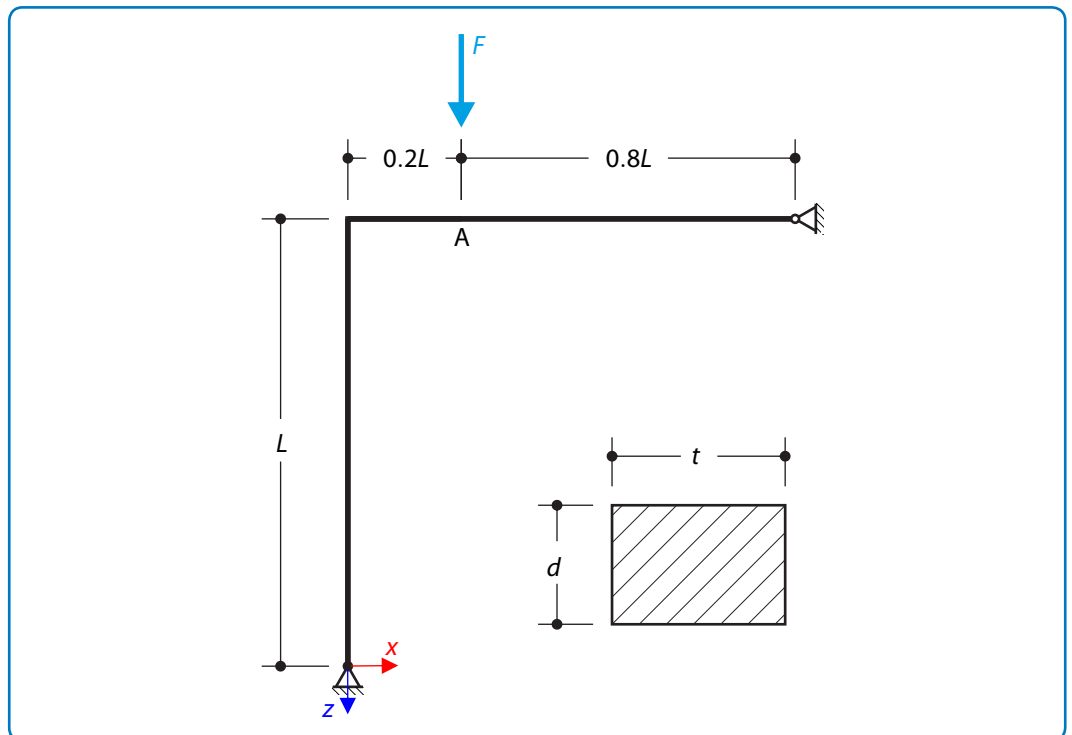
NAFEMS NL 7 – Lee´s Frame Buckling Problem

Description

A curved frame called Lee´s frame [1] is pinned at the end points and loaded by means of concentrated force at point A.

Determine the deflection ratio $\frac{u_z}{L}$ at point A in given load steps.

The problem is defined according The NAFEMS Non-linear Benchmarks [2] and it is described in **Figure 1** and by the following set of parameters.

Material	Isotropic	Modulus of Elasticity	E	71740.000	MPa
		Poisson's Ratio	ν	0.000	—
Geometry		Length	L	1.200	m
		Cross-section Width	d	0.020	m
		Cross-section Height	t	0.030	m
Load		Concentrated Force	F_z	31.900	kN

Figure 1: Problem sketch

RFEM Settings

- Modeled in RFEM 5.26.01
- Isotropic linear elastic material model is used

Results

Structure Files	Program	Solving Method
NL07.01	RFEM 5	Post-Critical Analysis – Modified Newton-Raphson
NL07.02	RFEM 5	Large Deformation Analysis – Dynamic Relaxation
NL07.03	RFEM 5 – RF-DYNAM Pro	Explicit Analysis

$\frac{F_zL^2}{EJ_y} = 18.552^*$	Target	RFEM 5	
	$\frac{u_z}{L}$ [m]	$\frac{u_z}{L}$ [m]	Ratio [-]
Post-Critical Analysis – Modified Newton-Raphson		0.356	0.875
Large Deformation Analysis – Dynamic Relaxation	0.407	0.324	0.796
Explicit Analysis		0.374	0.919
Abaqus Standard (Arc Length Method)		0.387	0.951

$\frac{F_zL^2}{EJ_y} = 31.887^*$	Target	RFEM 5	
	$\frac{u_z}{L}$ [m]	$\frac{u_z}{L}$ [m]	Ratio [-]
Post-Critical Analysis – Modified Newton-Raphson		0.781	0.996
Large Deformation Analysis – Dynamic Relaxation	0.784	0.781	0.996
Explicit Analysis		0.781	0.996
Abaqus Standard (Arc Length Method)		0.781	0.996

*Remark: The results at given ratios $\frac{F_zL^2}{EJ_y}$ can not be obtained directly. The linear interpolation of nearest points is used.
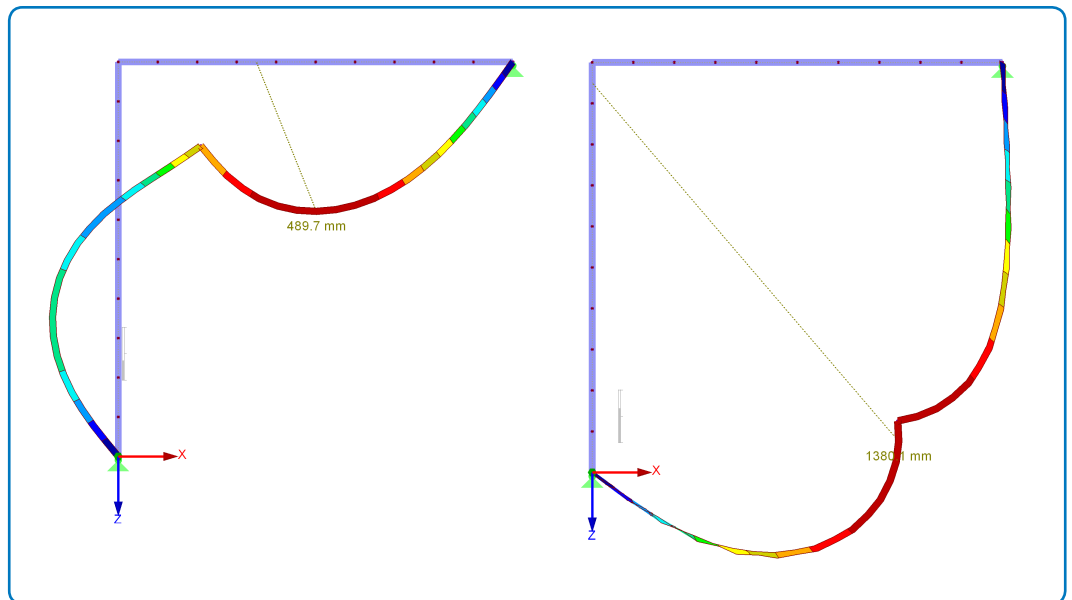
Figure 2: RFEM results – deformed shape of the frame for given ratios 18.552 and 31.887

References

[1] LEE, S.-L., MANUEL, F. S. and ROSSOW, E. C.. Large deflections and stability of elastic frame. *Journal of the Engineering Mechanics Division*, 94(2):521-548, 1968.

[2] THE INTERNATIONAL ASSOCIATION FOR THE ENGINEERING ANALYSIS COMMUNITY, *The NAFEMS Non-Linear Benchmarks*. NAFEMS Ltd., Glasgow, United Kingdom, 1989.