



**Program:** RFEM 5, RF-DYNAM Pro, RFEM 6

**Category:** NAFEMS Benchmark, Geometrically Linear Analysis, Isotropic Linear Elasticity, Dynamics, Member

**Verification Example:** NAFEMS FV 2 – Pin-Ended Double Cross – In Plane Vibration

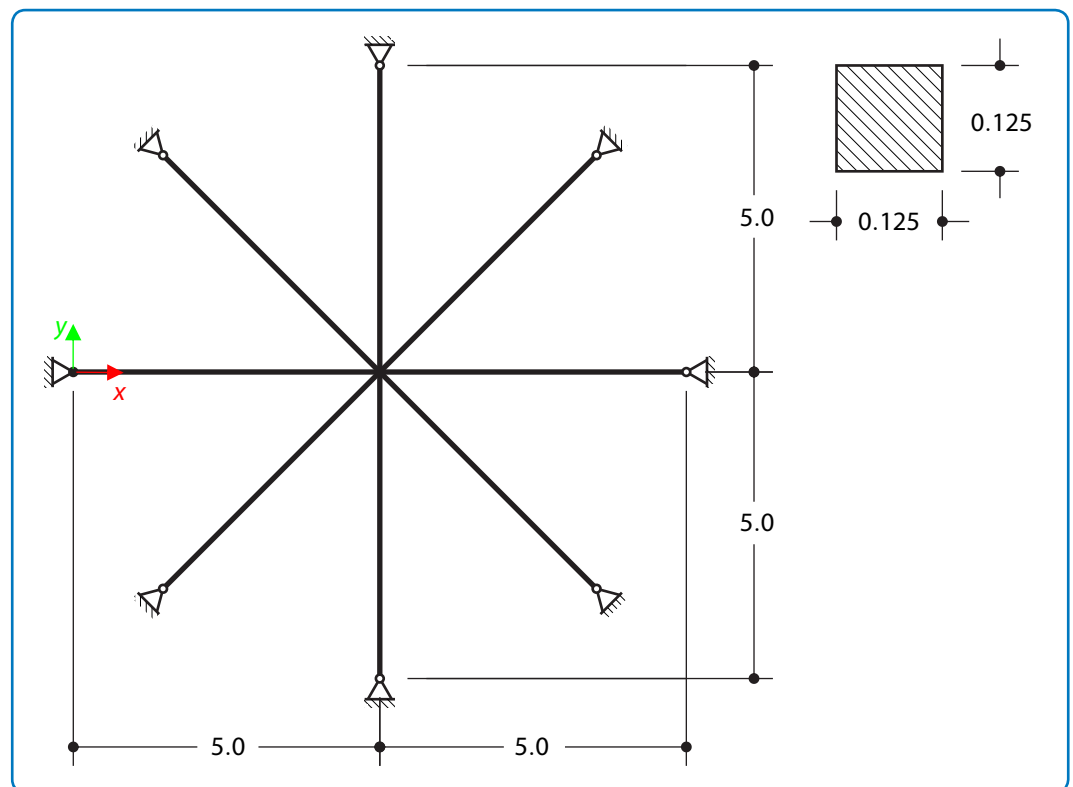
## NAFEMS FV 2 – Pin-Ended Double Cross – In Plane Vibration

### Description

Determine the first sixteen natural frequencies of a double cross with square cross-section, see **Figure 1**. Each of eight arms is modeled by means of four beam elements and has a pin support at the end ( $x$  and  $y$ -deflection is restricted). The vibrations are considered only in plane  $xy$ .

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

Material	Isotropic	Modulus of Elasticity	$E$	200000.000	MPa
		Poisson's Ratio	$\nu$	0.300	—
		Density	$\rho$	8000.000	$\text{kgm}^{-3}$



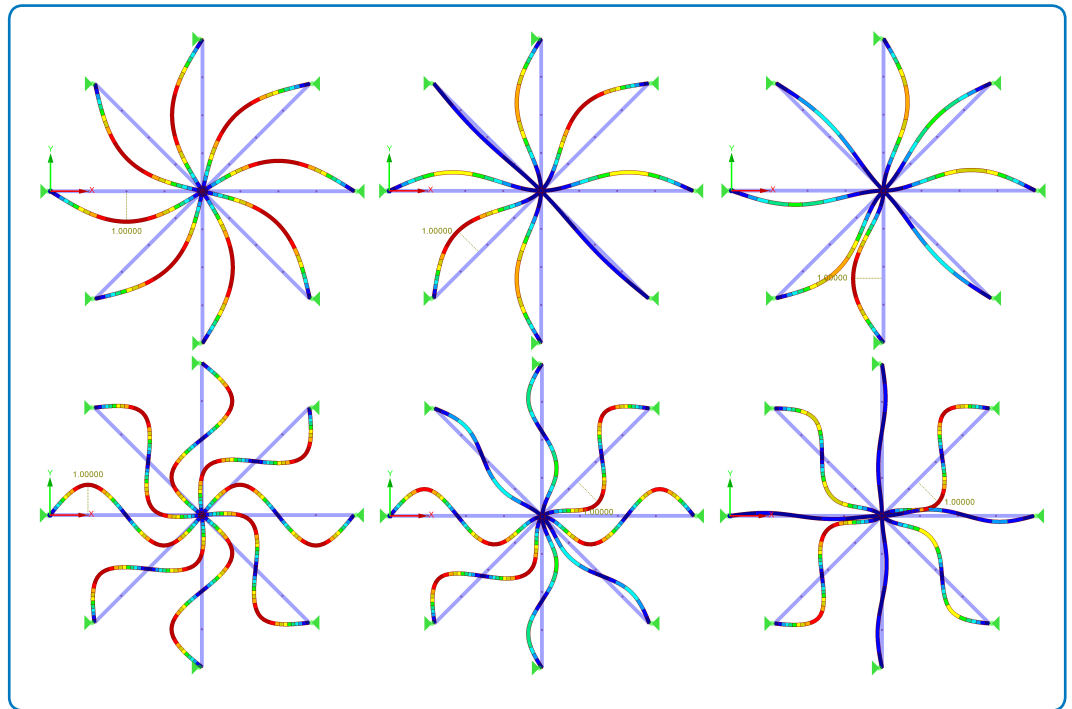
**Figure 1:** Problem sketch, dimensions are in meters

### RFEM Settings

- Modeled in RFEM 5.26.01 and RFEM 6.01
- Isotropic linear elastic material model is used
- Consistent mass matrix and Lanczos solver is used
- RF-DYNAM Pro module is used in RFEM 5
- Modal Analysis addon is used in RFEM 6

**Results**

Structure Files	Program
FV02.01	RFEM 5 – RF-DYNAM Pro, RFEM 6



**Figure 2:** RFEM 5 results - mode shapes overview

Mode Shape	Target	RFEM 5 – RF-DYNAM Pro		RFEM 6	
	$f$ [Hz]	$f$ [Hz]	Ratio [-]	$f$ [Hz]	Ratio [-]
1	11.336	11.339	1.000	11.336	1.000
2, 3	17.709	17.692	0.999	17.686	0.999
4, 5, 6, 7, 8	17.709	17.720	1.001	17.715	1.000
9	45.345	45.523	1.004	45.476	1.003
10, 11	57.390	57.425	1.001	57.362	1.000
12, 13, 14, 15, 16	57.390	57.745	1.006	57.681	1.005

**References**

- [1] THE INTERNATIONAL ASSOCIATION FOR THE ENGINEERING ANALYSIS COMMUNITY, *The Standard NAFEMS Benchmarks*. NAFEMS Ltd., Glasgow, United Kingdom, 2012.