Verification Example

Program: RFEM 5, RSTAB 8, RF-DYNAM Pro, DYNAM Pro

Category: Geometrically Linear Analysis, Dynamics, Member

Verification Example: 0117 – Double Mass Oscillator

0117 – Double Mass Oscillator

Description

A double–mass oscillator consists of two linear springs with stiffness k_1, k_2 and masses m_1, m_2, which are concentrated at the nodes. The self-weight of the springs is neglected. Determine the natural frequencies of the system. The problem is shown in **Figure 1** and is described by the following set of parameters.

System Properties	Mass	m_1	50.000	kg
		m_2	20.000	kg
	Spring Stiffness	k_1	10.000	kN/m
		k_2	20.000	kN/m

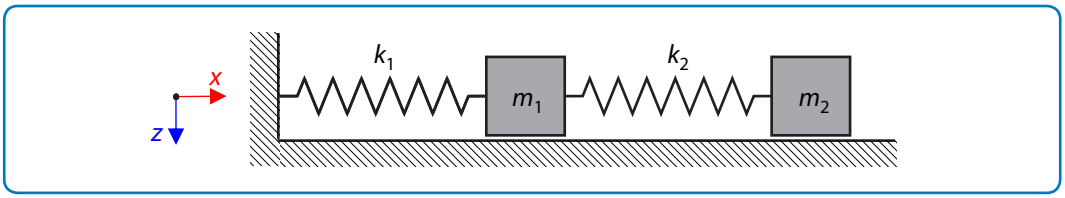

Figure 1: Problem Sketch

Analytical Solution

Natural oscillations of the double–mass system are described by the following system of second–order differential equations

$$m_1\ddot{u}_{x1} + k_1 u_{x1} - k_2(u_{x2} - u_{x1}) = 0, \tag{117 – 1}$$

$$m_2\ddot{u}_{x2} + k_2(u_{x2} - u_{x1}) = 0, \tag{117 – 2}$$

or in matrix form

$$\boldsymbol{M}\ddot{u}_x + \boldsymbol{K}u_x = 0, \tag{117 – 3}$$

$$\begin{bmatrix} m_1 & 0 \\ 0 & m_2 \end{bmatrix} \begin{bmatrix} \ddot{u}_{x1} \\ \ddot{u}_{x2} \end{bmatrix} + \begin{bmatrix} k_1 + k_2 & -k_2 \\ -k_2 & k_2 \end{bmatrix} \begin{bmatrix} u_{x1} \\ u_{x2} \end{bmatrix} = 0. \tag{117 – 4}$$

The eigenvalue problem

$$\det\left(\boldsymbol{K} - \Omega^2\boldsymbol{M}\right) = 0 \tag{117 – 5}$$

then yields the angular frequencies Ω_1 and Ω_2, whence the natural frequencies f_1, f_2 are, in turn, calculated.

$$f_1 = \frac{\Omega_1}{2\pi} \approx 1.861 \text{ Hz} \quad (117 - 6)$$

$$f_2 = \frac{\Omega_2}{2\pi} \approx 6.088 \text{ Hz} \quad (117 - 7)$$

RFEM 5 and RSTAB 8 Settings

- Modeled in RFEM 5.10.00 and RSTAB 8.10.00
- Subspace iteration method is used

Results

Structure Files	Program
0117.01	RFEM 5 – RF-DYNAM Pro
0117.02	RSTAB 8 – DYNAM Pro

Model	Analytical Solution	RFEM 5 / RSTAB 8	
	f_1 [Hz]	f_1 [Hz]	Ratio [-]
RFEM 5	1.861	1.861	1.000
RFEM 8		1.862	1.000

Model	Analytical Solution	RFEM 5 / RSTAB 8	
	f_2 [Hz]	f_2 [Hz]	Ratio [-]
RFEM 5	6.088	6.088	1.000
RSTAB 8		6.088	1.000