Verification Example

Program: RFEM 5, RSTAB 8

Category: Geometrically Linear Analysis, Isotropic Linear Elasticity, Member

Verification Example: 0211 – Eccentric Uniform Load

0211 – Eccentric Uniform Load

Description

A console made of round bar of diameter d is loaded by means of eccentric uniform load p in y-direction according to **Figure 1**. Determine the maximal deflection $u_{y,\max}$ and maximal twist $\varphi_{x,\max}$ of the console using geometrically linear analysis. The problem is described by the following set of parameters.

Material	Steel	Modulus of Elasticity	E	210000.000	MPa
		Poisson's Ratio	ν	0.300	–
Geometry		Length	L	1.000	m
		Diameter	d	20.000	mm
		Eccentricity	e_z	0.250	m
Load		Uniform	p	0.100	kN/m

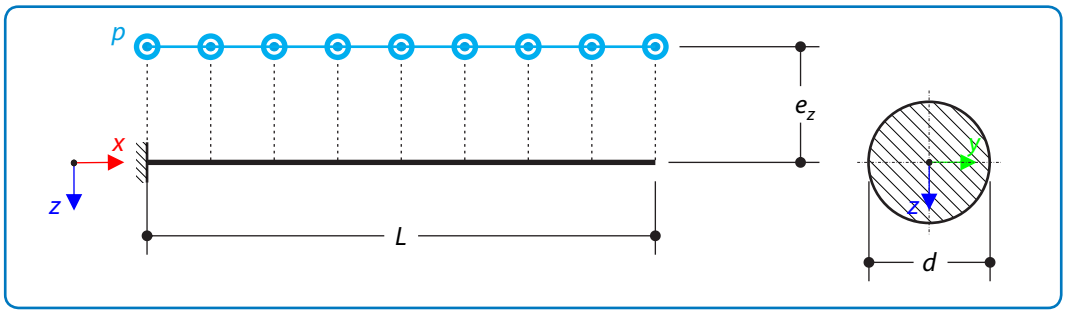

Figure 1: Problem sketch

Analytical Solution

Considering geometrically linear analysis, the maximal deflection of the console loaded by means of uniform load is defined by the following simple formula

$$u_{z,\max} = \frac{pL^4}{8EI_y} \approx 7.579 \text{ mm}, \qquad (211-1)$$

where I_y is the moment of inertia of the circular cross-section. Transverse eccentric uniform load p causes furthermore torque

$$M_x(x) = e_z p x. \qquad (211-2)$$

The twist of the console tip $\varphi_{x,\max}$ is defined by means of the following formula

$$\varphi_{x,\max} = \int_0^L \frac{M_x}{GJ} dx = \int_0^L \frac{e_z p x}{GJ} dx = \frac{e_z p L^2}{2GJ} \approx 0.0099 \text{ rad}, \qquad (211 - 3)$$

where G is the shear modulus and J is the torsional constant of the cross-section.

RFEM 5 and RSTAB 8 Settings

- Modeled in RFEM 5.19.01 and RSTAB 8.19.01
- The element size is $l_{FE} = 0.100$ m
- Isotropic linear elastic material model is used

Results

Structure Files	Program	Details
0211.01	RFEM 5	Eccentric Member Load
0211.02	RFEM 5	Rigid Members
0211.03	RSTAB 8	Rigid Members

Remark: The eccentricity in structure files 0211.02 and 0211.03 is modeled by means of 100 rigid members with concentrated force. It is not accurate model, that is why the results are not exact, but it demonstrates the advantage of the eccentric member load.

Model	Analytical Solution	RFEM 5 / RSTAB 8	
	$u_{y,\max}$ [mm]	$u_{y,\max}$ [mm]	Ratio [-]
RFEM 5, Eccentric Member Load	7.579	7.579	1.000
RFEM5, Rigid Member		7.669	1.012
RSTAB 8, Rigid Member		7.678	1.013

Model	Analytical Solution	RFEM 5 / RSTAB 8	
	$\varphi_{x,\max}$ [rad]	$\varphi_{x,\max}$ [rad]	Ratio [-]
RFEM 5, Eccentric Member Load	0.0099	0.0099	1.000
RFEM5, Rigid Member		0.0099	1.000
RSTAB 8, Rigid Member		0.0100	1.010