0058 – Scaffolding Nodal Support - Overcoming the Limit

Description

Consider a rigid scaffolding tube, fixed at the bottom using the Scaffolding Nodal Support and loaded by both a moment $\boldsymbol{M}$ and a force of magnitude P_z. Self-weight is not considered. The problem is described by the following set of input parameters.

Material	Steel	Modulus of Elasticity	E	210.000	GPa
Geometry	Scaffolding tube	Length	L	1.000	m
		Cross-Section in 0066.01		RO244.5x25	
		Cross-Section in 0066.02		Rigid	
Loading	Scaffolding tube	Moment	M_x	0.000	kNm
			M_y	1.350	kNm
		Force	P_Z	50.000	kN
Support properties	Scaffolding Nodal Support	Maximal Eccentricity	$e_{\max}$	0.025	m
		Stiffness	C	20.000	kNm/rad
	Nodal support	Stiffness	$C_{\varphi,x} = C_{\varphi,y}$	1.000	kNm/rad

Example presumptions:

- Boundary conditions $u_x = u_y = u_z = \varphi_z = 0$ for $z = 0$
- Rotational degrees of freedom around x and y-axis are elastically fixed at the top of the beam
- The behaviour of the Scaffolding Nodal Support depends on a M-Phi diagram, where $M = eP_z$ in accordance with ČSN EN 12811-1 norm [1]. See **Figure 2**.

Consider a moment $\boldsymbol{M}_1 = [0, M_y, 0]$ acting around y-axis and determine the maximal radial deflection $u_{x,\max}$ of the structure in two cases:

- The beam is considered infinitely rigid.
- The physically unrealistic rigid beam is modeled using a stiff-enough beam with RO244.5x25 cross-section.

We point out that this particular example is only a slight modification of verification example 0063. The main difference is that the value of loading moment now exceeds the limit given by Maximal Eccentricity of Scaffolding Nodal Support. Roughly speaking, the Scaffolding Nodal Support is not strong enough to maintain equilibrium and the presence of an additional elastic support at the top of the beam is needed.

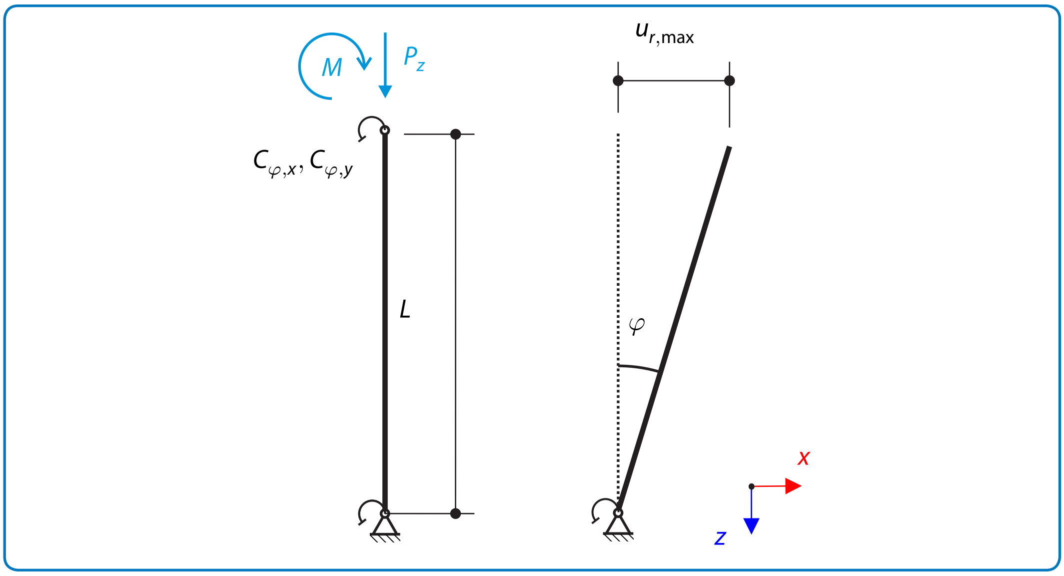

Figure 1: Problem Sketch and Solution

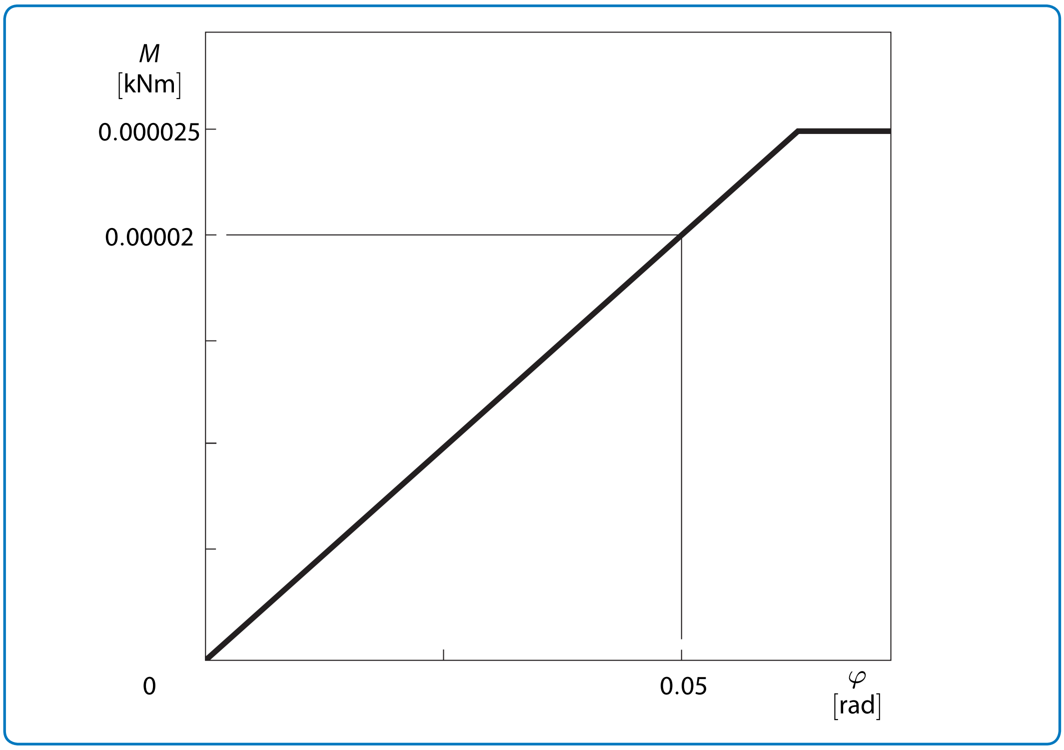

Figure 2: Relationship between magnitude of moment $M = eP_z$ and angle φ for $P_z = 1$ N. In this case the value of moment equals the value of Eccentricity. The same diagram is used in RFEM to define a non-linearity of Scaffolding Nodal Support.

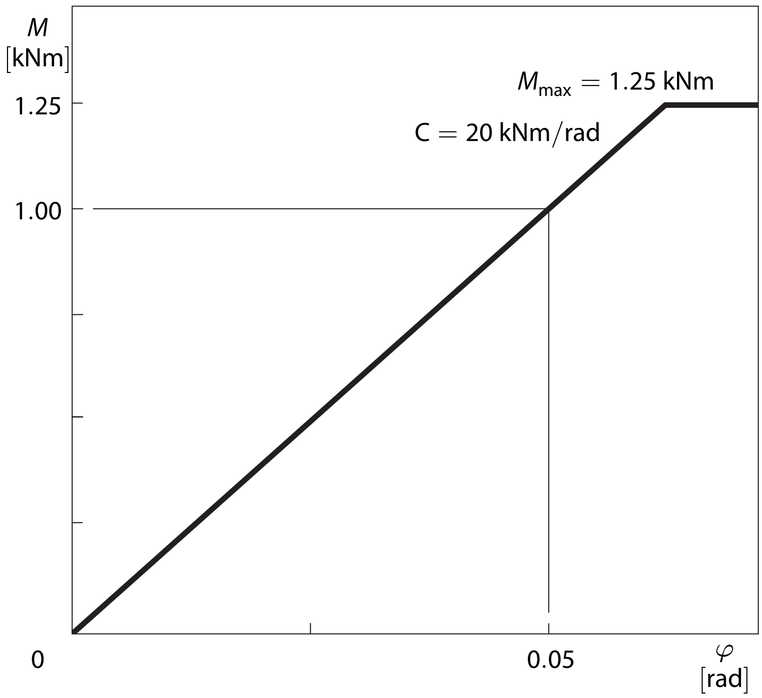

Figure 3: Relationship between magnitude of moment $M = eP_z$ and angle φ for $P_z = 50$ kN.

Analytical Solution

We can get the solution of both cases immediately by reading the values from **Figure 3**.

$$\varphi_{max} = \frac{M_y - M_{max}}{C_{\varphi,y}} = 0.1 \text{ rad} \tag{58 – 1}$$

This in turn yields the maximal radial deflection $u_{x,max}$.

$$u_{x,max} \approx l\varphi_{max} = 100.0 \text{ mm} \tag{58 – 2}$$

Please note that we have used 1st order theory approximation.

RFEM 5 Settings

- Modeled in RFEM 5.04.0024
- The element size is $l_{FE} = 0.50$ m
- Geometrically linear analysis is considered
- The number of increments 5
- Support Conditions: Diagram - FZ′/PhiX′PhiY′ is given by **Figure 2**

Results

Structure File	Material Model	Description
0058.01	Isotropic Linear Elastic	RO244.5x25 cross-section
0058.02	Rigid	-

Beam type	Analytical solution*	RFEM 5	
	$u_{r,\mathrm{max}}$ [mm]	$u_{r,\mathrm{max}}$ [mm]	Ratio [-]
RO244.5x25 cross-section	100.000	99.972	1.000
Rigid	100.000	100.000	1.000

* Analytical solution was derived using rigid beams and 1st order theory in all cases

References

[1] ČSN EN 12811-1, *Dočasné stavební konstrukce - Část 1: Pracovní lešení - Požadavky na provedení a obecný návrh.* 2004.