Benchmark Example No. 17

Lateral Torsional Buckling

SOFiSTiK | 2023

VERiFiCATiON
BE17 Lateral Torsional Buckling

VERiFiCATiON Manual, Service Pack 2023-10 Build 44

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Front Cover

Volkstheater, Munich   Photo: Florian Schreiber

Overview	
Element Type(s):	B3D
Analysis Type(s):	STAT, GNL
Procedure(s):	
Topic(s):	
Module(s):	ASE
Input file(s):	lateral_torsional_buckling.dat

1 Problem Description

The problem consists of a single span beam with an initial geometrical imperfection at the middle, subjected to a uniformly distributed load q_z, as shown in Fig. 1. The structure is examined for lateral torsional buckling.

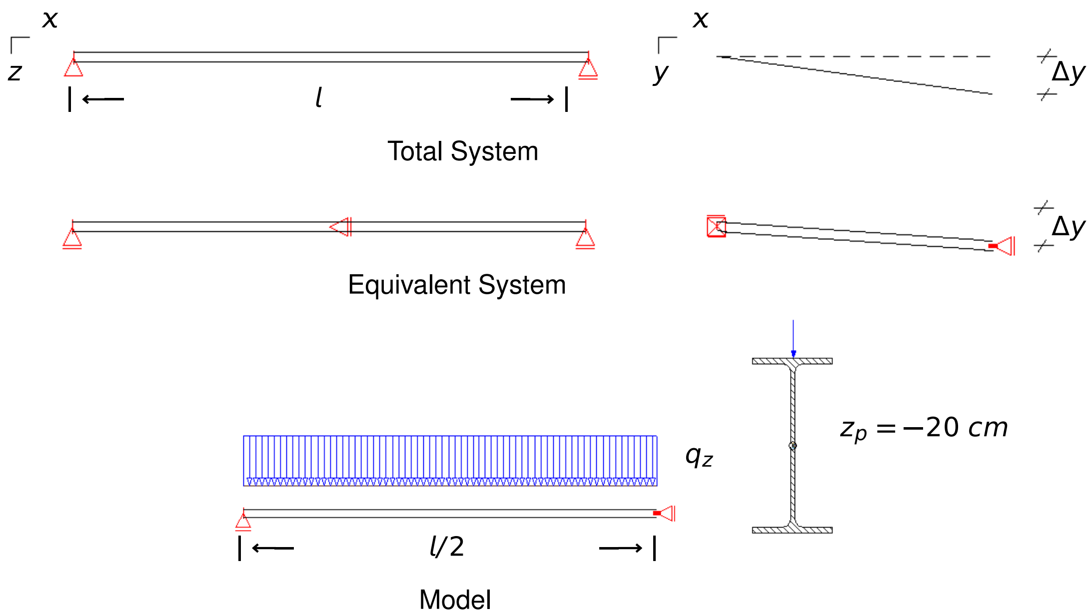

Figure 1: Problem Description

2 Reference Solution

The I-beam of Fig. 1 has an initial geometrical imperfection in the y-direction $\Delta y = l/200 = 3.0\ cm$. Using the symmetry of the equivalent system the model can be reduced to half as shown at Fig. 1. Due to the bending moments, the load application on the upper flange of the beam (z_p) and the imperfection, the beam is at risk for lateral torsional buckling. In order to account for this effect, third order theory has to be utilised.

3 Model and Results

The properties of the model [1] are defined in Table 1. A standard steel material is used as well as a standard rolled steel profile with properties according to DIN 1025-5. A safety factor $\gamma_M = 1.1$ is used, which according to DIN 18800-2 it is applied both to the yield strength and the stiffness. The loading is applied at the upper flange as shown in Fig. 1. Furthermore, the self weight and the shear deformations are neglected. At the supports the warping is not constrained.

Table 1: Model Properties

Material Properties	Geometric Properties	Loading
$S\,355$, $\gamma_M = 1.1$	$l = 6\,m$, $\Delta y = 3\,cm$	$q_z = 10\,kN/m$
$C_M = 490000\,cm^6$	IPE 400 [2]	$z_p = -20\,cm$

The results are presented in Table 2. It is observed that second-order theory (TH. II) fails to capture the moments with respect to the z-axis, therefore third-order theory (TH. III) has to be used. It has to be noted that the reference results are according to [1], where they are computed with another finite element software, and not with respect to an analytical solution.

Table 2: Results

	$C_M = 490000\ [cm^6]$		Ref. [1]	$C_M = 0$		Ref. [1]
	TH. II	TH. III		TH. II	TH. III	
$u_y\ [cm]$	0.094	0.082	0.089	0.184	0.158	0.172
$u_z\ [cm]$	0.422	0.425	0.424	0.470	0.479	0.475
$phi_x\ [rad]$	0.0167	0.0166	0.0167	0.0367	0.0363	0.0365
$M_x\ [kN\,m]$	0.439	0.437	0.438	0.510	0.504	0.508
$M_y\ [kN\,m]$	45.0	45.0	45.0	45.0	45.0	45.0
$M_z\ [kN\,m]$	0.001	0.747	0.752	0.001	1.627	1.641
$M_\omega\ [kN\,m]$	0.606	0.604	0.607	0.0	0.0	0.0

4 Conclusion

This example examines the lateral torsional buckling of beams. It has been shown that the behaviour of the beam is captured accurately.

5 Literature

[1] V. Gensichen and G. Lumpe. *Zur Leistungsfähigkeit, korrekten Anwendung und Kontrolle räumlicher Stabwerksprogramme*. Stahlbau Seminar 07.

[2] K. Holschemacher. *Entwurfs- und Berechnungstafeln für Bauingenieure*. 3rd. Bauwerk, 2007.