Benchmark Example No. 16

Torsion due to Biaxial Bending

SOFiSTiK | 2018

VERiFiCATiON MANUAL
BE16: Torsion due to Biaxial Bending

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Front Cover

Project: New SOFiSTiK Office, Nuremberg | Contractor: WOLFF & MLLER, Stuttgart | Architecture: WABE-PLAN ARCHITEKTUR, Stuttgart | Structural Engineer: Boll und Partner. Beratende Ingenieure VBI, Stuttgart | MEP: GM Planen + Beraten, Griesheim | Lead Architect: Gerhard P. Wirth gpwirtharchitekten, Nuremberg | Vizualisation: Armin Dariz, BiMOTiON GmbH

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

1 Problem Description

The problem consists of a beam subjected to transverse load P_z and a lateral load P_y, as shown in Fig. 1. The effect of torsion due to biaxial bending is examined.

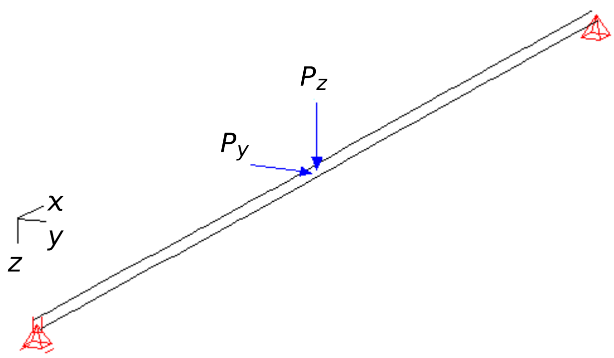

Figure 1: Problem Description

2 Reference Solution

For an I-beam subjected to biaxial bending, without the action of a normal force, it follows directly from the beam theory that a torsional moment will inevitably appear, even if the cross-section is double symmetric, the load is centrically applied, and the beam is statically determined. 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 cross-section with a standard rolled steel shape. 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. 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
$S\,355$	$l = 5\,m$	$P_z = 20\,kN$
$\gamma_M = 1.1$	$IPE\ 300$ [2] [3]	$P_y = 4\,kN$
$C_M = 125900\,cm^6$		

The results are presented in Table 2. It has to be noted that the reference results are according to [1] and [4], where they are computed with another finite element software, and not with respect to an analytical solution.

Table 2: Results

max | |	$C_M = 125900$ $[cm^6]$	Ref. [1]	$C_M = 0$	Ref. [1]
ϕ_x $[rad]$	0.0316	0.0315	0.0321	0.0321
M_x $[kN\,m]$	0.183	0.185	0.185	0.189
M_y $[kN\,m]$	24.88	24.9	24.85	24.9
M_z $[kN\,m]$	5.57	5.6	5.71	5.7

4 Conclusion

This example presents a case where torsion is induced to the system because of biaxial bending. 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] R. Kindmann, M. Kraus, and H. J. Niebuhr. *Stahlbau Kompakt, Bemessungshilfen, Profiltabellen*. Verlag Stahleisen, 2006.

[3] R. Kindmann. "Neue Berechnungsformel für das IT von Walzprofilen und Berechnung der Schubspannungen". In: *Stahlbau 75* (2006).

[4] V. Gensichen and G. Lumpe. "Zur Leistungsfähigkeit, korrekten Anwendung und Kontrolle von EDV-Programmen für die Berechnung räumlicher Stabwerke im Stahlbau". In: *Stahlbau 77 (Teil 2)* (2008).