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Benchmark Example No. 16

Torsion due to Biaxial Bending

VERiFiCATION
BE16 Torsion due to Biaxial Bending

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The user of the program is solely responsible for the applications. We strongly encourage the user to test the correctness of all calculations at least by random sampling.

Front Cover

6th Street Viaduct, Los Angeles Photo: Tobias Petschke

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.

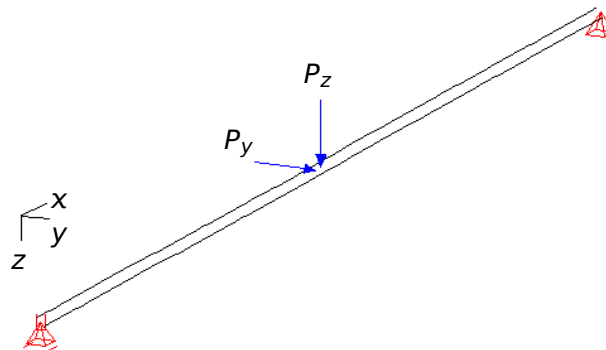


Figure 1: Problem Description

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 centrally 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	$l = 5 \text{ m}$	$P_z = 20 \text{ kN}$
$\gamma_M = 1.1$	IPE 300 [2] [3]	$P_y = 4 \text{ kN}$
$C_M = 125900 \text{ cm}^6$		

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]
$\phi_x [rad]$	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).