

Benchmark Example No. 15

## Flexural and Torsional Buckling

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**VERiFiCATION**  
**BE15 Flexural and Torsional Buckling**

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**SOFiSTiK AG**

HQ Nuremberg  
Flataustraße 14  
90411 Nürnberg  
Germany

T +49 (0)911 39901-0  
F +49(0)911 397904

Office Garching  
Parkring 2  
85748 Garching bei München  
Germany

T +49 (0)89 315878-0  
F +49 (0)89 315878-23

[info@sofistik.com](mailto:info@sofistik.com)  
[www.sofistik.com](http://www.sofistik.com)

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The manual and the program have been thoroughly checked for errors. However, SOFiSTiK does not claim that either one is completely error free. Errors and omissions are corrected as soon as they are detected.

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**

Project: Queensferry Crossing | Photo: Bastian Kratzke

### Overview

<b>Element Type(s):</b>	B3D
<b>Analysis Type(s):</b>	STAT, GNL
<b>Procedure(s):</b>	STAB
<b>Topic(s):</b>	
<b>Module(s):</b>	ASE
<b>Input file(s):</b>	<a href="#">flex_tors_buckling.dat</a>

## 1 Problem Description

The problem consists of a standard I-beam, subjected to a compressive load  $P$  and supported as shown in Fig. 1. The flexural and torsional buckling load is determined.



Figure 1: Problem Description

## 2 Reference Solution

For the rolled steel profiles, such as *IPe* 300, the torsional buckling is generally only decisive, when the buckling length for torsional buckling  $s_{\theta}$  is significantly larger than the one for the flexural buckling  $s_z$ , and at the same time the slenderness ratio is low [1]. The analysed model fulfils the above prerequisites. The flexural buckling load is:

$$P_{buck_z} = \frac{\pi^2 EI_z}{s_z^2 \gamma_M}, \quad (1)$$

whereas the torsional buckling load is:

$$P_{buck\theta} = \frac{1}{i_m^2 \gamma_M} \left( GI_T + \frac{\pi^2 EC_M}{s_\theta^2} \right), \quad (2)$$

where  $EI_z$  the flexural rigidity,  $C_M$  the warping modulus,  $\gamma_M$  a safety factor,  $G$  the shear modulus,  $I_T$  the torsional moment and  $i_M$  is the polar radius of gyration calculated as following:

$$i_M = \frac{I_y + I_z}{A}. \quad (3)$$

### 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. Furthermore, the self weight and the shear deformations are neglected. At all the supports the warping is not constrained.

Table 1: Model Properties

Material Properties	Geometric Properties	Loading
S 355	$s_\theta = 5$ or $6$ m	$P = 600$ kN
$\gamma_M = 1.1$	$s_z = 2.5$ or $3$ m	
$C_M = 125900$ cm <sup>6</sup>	IPE 300 [2]	
	$I_y = 8360$ cm <sup>4</sup>	
	$I_z = 604$ cm <sup>4</sup>	
	$A = 53.81$ cm <sup>2</sup>	

The corresponding results are presented in Table 2. Figure 2 shows the deformed shape of the structure for the first and second buckling eigenvalues. It is obvious that the first one corresponds to the torsional buckling while the second one to the flexural.

Table 2: Results

	$s_\theta = 5.0$ [m] / $s_z = 2.5$ [m]		$s_\theta = 6.0$ [m] / $s_z = 3.0$ [m]	
	$P_{buck_z}$ [kN]	$P_{buck_\theta}$ [kN]	$P_{buck_z}$ [kN]	$P_{buck_\theta}$ [kN]
SOF.	1820.92	1462.87	1264.53	1288.78
Exact	1820.89	1462.87	1264.51	1288.78
Ref. [3]	1818	1459	1264	1285

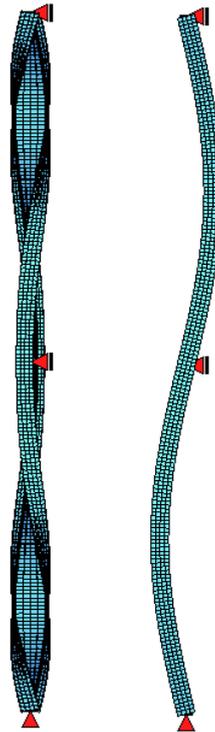


Figure 2: Buckling Eigenvalues

## 4 Conclusion

This example presents the determination of torsional and flexural buckling loads. 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 Berechnungstabellen für Bauingenieure*. 3rd. Bauwerk, 2007.
- [3] 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).