SOFiSTiK

Benchmark Example No. 15

Flexural and Torsional Buckling

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VERiFiCATiON
BE15 Flexural and Torsional Buckling

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Front Cover

6th Street Viaduct, Los Angeles Photo: Tobias Petschke

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

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.

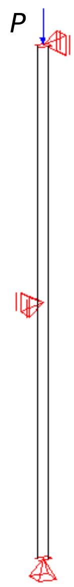

Figure 1: Problem Description

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_θ 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:

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

whereas the torsional buckling load is:

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

where EI_z the flexural rigidity, C_M the warping modulus, γ_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:

$$i_M = \frac{I_y + I_z}{A}. \tag{3}$$

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 $3\,m$	
$C_M = 125900\,cm^6$	$IPE\,300$ [2]	
	$I_y = 8360\,cm^4$	
	$I_z = 604\,cm^4$	
	$A = 53.81\,cm^2$	

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

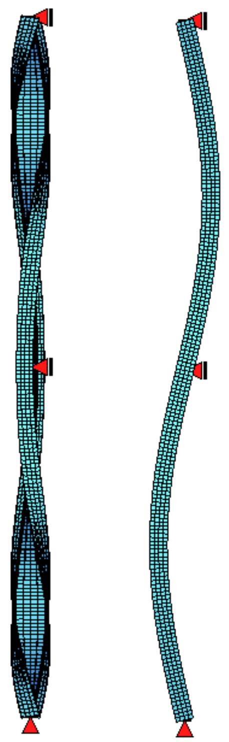

Figure 2: Buckling Eigenvalues

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 Berechnungstafeln 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).