Benchmark Example No. 5

Bending of a T-beam

SOFiSTiK | 2023

VERiFiCATiON
BE5 Bending of a T-beam

VERiFiCATiON Manual, Service Pack 2023-10 Build 44

SOFiSTiK AG

HQ Nuremberg	Office Garching
Flataustraße 14	Parkring 2
90411 Nürnberg	85748 Garching bei München
Germany	Germany
T +49 (0)911 39901-0	T +49 (0)89 315878-0
F +49(0)911 397904	F +49 (0)89 315878-23

info@sofistik.com
www.sofistik.com

Front Cover

Volkstheater, Munich   Photo: Florian Schreiber

Overview

Element Type(s):	B3D
Analysis Type(s):	STAT
Procedure(s):	
Topic(s):	
Module(s):	AQB, ASE
Input file(s):	t_beam.dat

1 Problem Description

An asymmetric T-beam is supported as shown in Fig. 1 and subjected to uniform bending M_z. Determine the maximum tensile and compressive bending stresses.

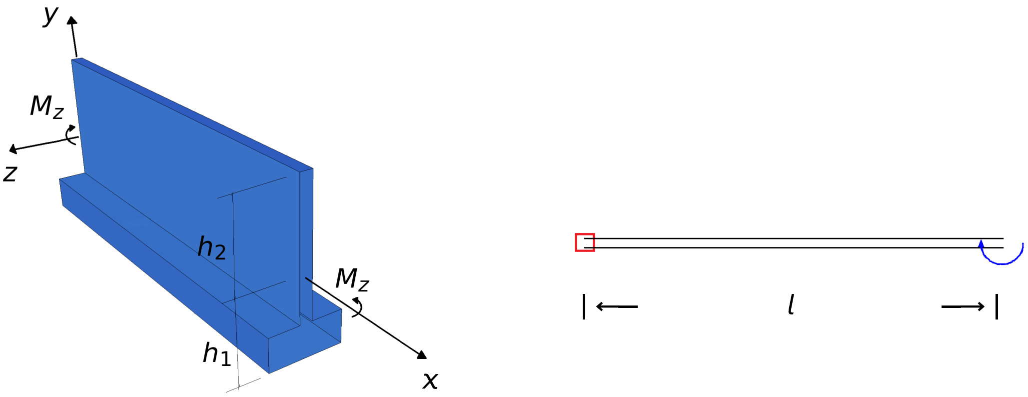

Figure 1: Model Properties

2 Reference Solution

According to the discussion in Benchmark Example no. 3, it follows that the maximum tensile and compressive stresses in a beam in pure bending are proportional to the distances of the most remote fibers from the neutral axis of the cross-section. When the centroid of the cross-section is not at the middle of the depth, as, for instance, in the case of a T-beam, let h_1 and h_2 denote the distances from the neutral axis to the outermost fibers in the downward and upward directions (Fig. 1) respectively. Then for a bending moment M_z, we obtain the maximum tensile and compressive stresses [1]:

$$\sigma_{max} = \frac{M_z h_1}{I_z} \qquad \text{and} \qquad \sigma_{min} = -\frac{M_z h_2}{I_z}. \tag{1}$$

3 Model and Results

The properties of the model are defined in Table 1. Distances from the centroid to the top and bottom of the beam are calculated as 14 cm and 6 cm respectively. The results are presented in Table 2. Figure 2 shows the distribution of the stresses along the cross-section.

Table 1: Model Properties

Material Properties	Geometric Properties	Loading
$E = 30000\,MPa$	$l = 1\,m$	$M_z = 100\,kNm$
	$h = 20\,cm$	
	$h_1 = 6\,cm$, $h_2 = 14\,cm$	
	$b = 9\,cm$	
	$t_{web} = 1.5\,cm$	
	$t_{flange} = 4\,cm$	
	$I_z = 2000\,cm^4$	

Table 2: Results

	SOF.	Ref.
σ_{max} [MPa]	300	300
σ_{min} [MPa]	-700	-700

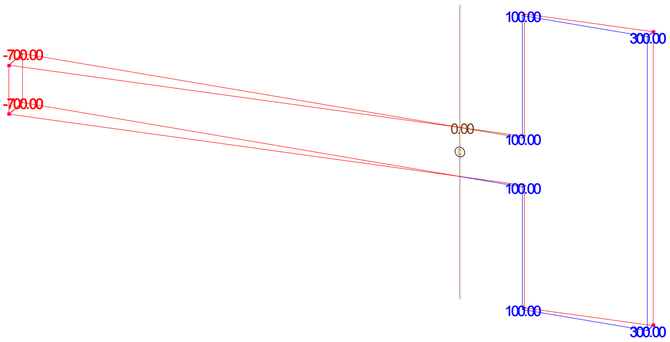

Figure 2: Distribution of Stresses

4 Conclusion

This example shows the derivation of stresses for beams with asymmetric cross-section in which the centroid of the cross-section is not at the middle of the depth. It has been shown that the behaviour of the beam is captured with an excellent accuracy.

5 Literature

[1] S. Timoshenko. *Strength of Materials, Part I, Elementary Theory and Problems*. 2nd. D. Van Nostrand Co., Inc., 1940.