Verification Example

Program: RFEM 5

Category: Geometrically Linear Analysis, Isotropic Nonlinear Elasticity, Isotropic Plasticity, Orthotropic Plasticity, Member, Plate, Solid

Verification Example: 0006 – Comparison of Nonlinear Material Models

0006 – Comparison of Nonlinear Material Models

Description

A beam with length L and cross-section VS 150x18 is fixed at both ends and loaded in the center by the forces F_X, F_Y and F_Z. Neglecting its self-weight and assuming only small deformations, determine deflections of the structure u_X, u_Y, u_Z and u. Compare the results obtained by considering the different nonlinear material models.

Material	Steel S 235	Modulus of Elasticity	E	210000.000	MPa
		Poisson's ratio	ν	0.300	–
		Yield Strength	f_y	235.000	MPa
Geometry	Beam	Length	L	2000.000	mm
		Width	b	100.000	mm
		Height	h	150.000	mm
		Flange Thickness	t	8.000	mm
		Web Thickness	s	4.800	mm
Load	Force	x-direction	F_X	600.000	kN
		y-direction	F_Y	6.000	kN
		z-direction	F_Z	60.000	kN

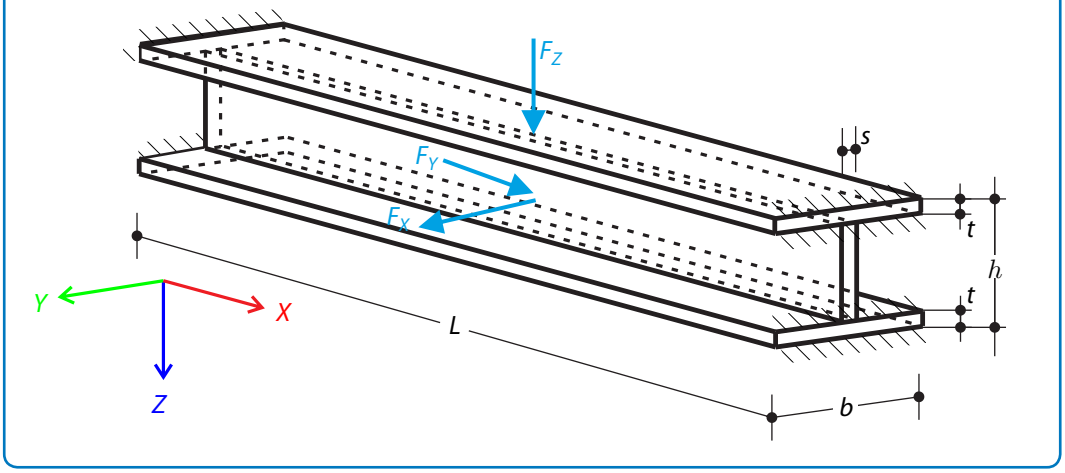

Figure 1: Problem sketch

Analytical Solution

There is no analytical solution available, the example serves only for the purpose of the different material models comparison.

RFEM 5 Settings

- Modeled in version RFEM 5.05.1197
- The element size is $l_{FE} = 0.010$ m
- Geometrically linear analysis is considered
- The Mindlin plate theory is used
- The number of increments is 10
- Shear stiffness of members is activated

Results

Structure File	Entity	Material Model	Strain Hypothesis	Nonsymmetric Direct Solver
0006.01	Member	Isotropic Plastic 1D	-	No
0006.02	Plate	Isotropic Plastic 2D/3D	-	No
0006.03	Solid	Isotropic Plastic 2D/3D	-	No
0006.04	Plate	Isotropic Nonlinear Elastic 2D/3D	von Mises	Yes
0006.05	Solid	Isotropic Nonlinear Elastic 2D/3D	von Mises	Yes
0006.06	Plate	Isotropic Nonlinear Elastic 2D/3D	Tresca	Yes
0006.07	Solid	Isotropic Nonlinear Elastic 2D/3D	Tresca	Yes
0006.08	Plate	Orthotropic Plastic 2D	-	No
0006.09	Solid	Orthotropic Plastic 3D	-	No
0006.10	Member	Isotropic Linear Elastic	-	No
0006.11	Plate	Isotropic Linear Elastic	-	No
0006.12	Solid	Isotropic Linear Elastic	-	No

Linear Material Models

Quantity	Member Isotropic Linear Elastic	Plate Isotropic Linear Elastic	Solid Isotropic Linear Elastic
	[mm]	[mm]	[mm]
u_X	0.638	0.639	0.650
u_Y	0.923	0.924	0.947
u_Z	1.903	1.865	1.919
u	2.209	2.172	2.219

Nonlinear Material Models

Quantity	Member Isotropic Plastic 1D	Plate Isotropic Plastic 2D/3D	Solid Isotropic Plastic 2D/3D
	[mm]	[mm]	[mm]
u_X	0.666	0.710	0.736
u_Y	1.323	1.806	1.761
u_Z	2.122	2.310	2.299
u	2.588	3.009	2.966

Quantity	Plate Isotropic Nonlinear Elastic 2D/3D von Mises	Solid Isotropic Nonlinear Elastic 2D/3D von Mises	Plate Isotropic Nonlinear Elastic 2D/3D Tresca
	[mm]	[mm]	[mm]
u_X	0.713	0.748	0.787
u_Y	1.839	1.860	2.439
u_Z	2.332	2.356	2.829
u	3.047	3.074	3.811

Quantity	Solid Isotropic Nonlinear Elastic 2D/3D Tresca	Plate Orthotropic Plastic 2D	Solid Orthotropic Plastic 3D
	[mm]	[mm]	[mm]
u_X	0.796	0.790	0.887
u_Y	2.197	2.467	2.817
u_Z	2.611	2.845	3.121
u	3.482	3.842	4.278

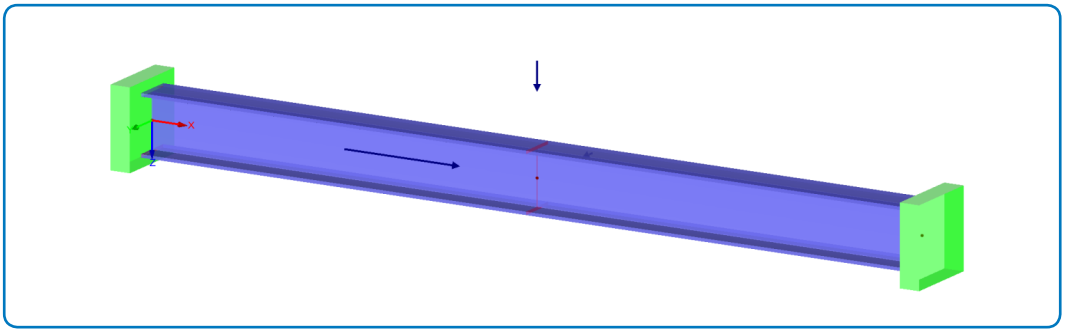

Figure 2: Member

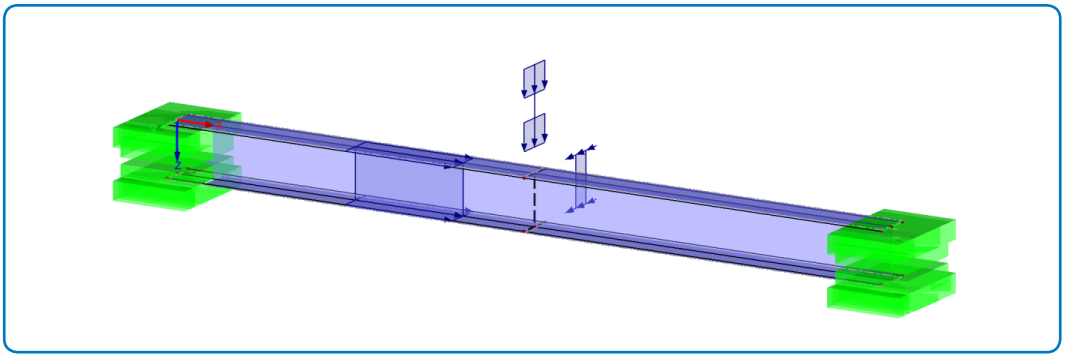

Figure 3: Plates

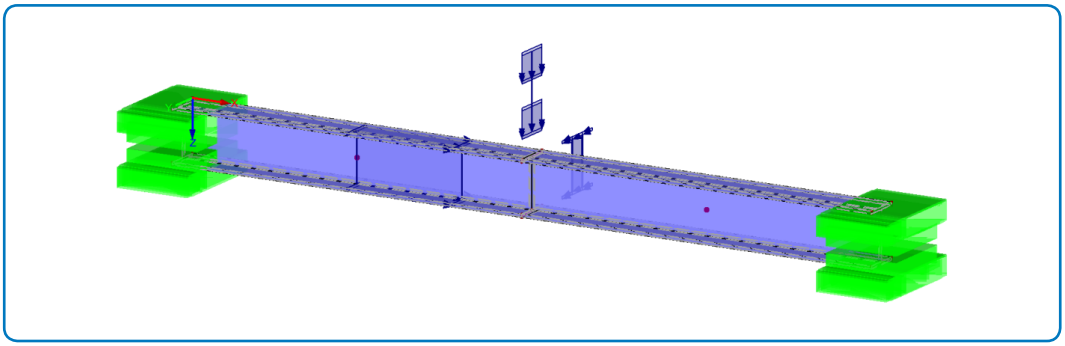

Figure 4: Solid