0011 – Tapered Timber Beam in Plasticity

Description

A timber beam, reinforced by two steel plates at its ends, is loaded by the pressure p and supported according to the **Figure 1**. Wood fibres (direction of E_x) are parallel to the upper loaded side of the beam. The plastic surface is described according to the Tsai-Wu plasticity theory using strengths below. The problem is described by the following set of parameters.

Material	Steel	Modulus of Elasticity	E	210000.000	MPa
		Poisson's Ratio	ν	0.300	—
	Timber	Modulus of Elasticity	E_x	12000.000	MPa
			$E_y = E_z$	400	MPa
		Poisson's Ratios	$\nu_{yz} = \nu_{xz} = \nu_{xy}$	0.000	—
		Shear Modulus	G_{yz}	200.000	MPa
			$G_{xz} = G_{xy}$	700.000	MPa
		Tensile Plastic Strength	$f_{t,x} = f_{t,z}$	24.000	MPa
			$f_{t,y}$	16.971	MPa
		Compressive Plastic Strength	$f_{c,x} = f_{c,z}$	24.000	MPa
			$f_{c,y}$	16.971	MPa
		Shear Plastic Strength	$f_{v,xz} = f_{v,xy}$	2.700	MPa
			$f_{v,yz}$	1.000	MPa
Geometry	Timber	Length	L	10.000	m
		Thickness	t	0.120	m
		Left Side Height	h_1	0.600	m
		Right Side Height	h_1	1.200	m
	Steel Plates	Width	b	0.010	m
Load		Pressure	p	0.300	MPa

Small deformations are considered and the self-weight is neglected in this example. Determine the maximum deflection $u_{z,max}$ and the stress σ_x at the test point.
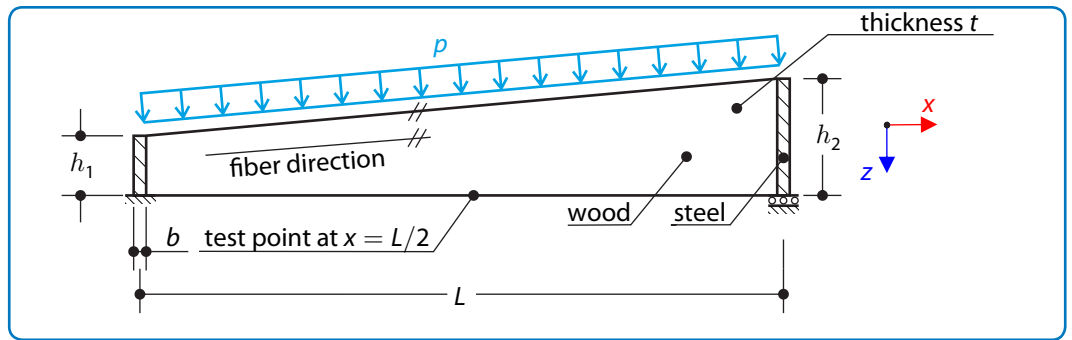
Figure 1: Problem sketch

Analytical Solution

Analytical solution is not available for this example.

RFEM 5 Settings

- Modeled in RFEM 5.16.01
- The element size is $l_{FE} = 0.060$ m
- Geometrically linear analysis is considered
- The number of increments is 10

Results

Structure File	Entity	Material model
0011.01	Solid	Orthotropic Plastic 3D
0011.02	Plate	Orthotropic Plastic 2D

Linear Elasticity Results: $u_{z,max}$ [mm]	
RFEM 5 (Solid)	RFEM 5 (Plate)
-68.515	68.520

ANSYS 15 (SOLID45, 3D)*	RFEM 5 (Orthotropic Plastic 3D)		RFEM 5 (Orthotropic Plastic 2D)	
$u_{z,max}$ [mm]	$u_{z,max}$ [mm]	Ratio [-]	$u_{z,max}$ [mm]	Ratio [-]
-82.252	-86.515	1.052	-86.035	1.046

ANSYS 15 (SOLID45, 3D)*	RFEM 5 (Orthotropic Plastic 3D)		RFEM 5 (Orthotropic Plastic 2D)	
σ_x [MPa]	σ_x [MPa]	Ratio [-]	σ_x [MPa]	Ratio [-]
21.468	21.297	0.992	24.000	1.118

* Remark: Numerical solution in ANSYS 15 was carried out by the company Designtec s.r.o.