Program: RFEM 5

Category: Geometrically Linear Analysis, Orthotropic Plasticity, Plate, Solid

Verification Example: 0012 – Locally Loaded Timber Beam in Plasticity

0012 – Locally Loaded Timber Beam in Plasticity

Description

A timber beam, reinforced by two steel plates on its ends, is loaded by a pressure p and supported according to the **Figure 1**. Wood fibers (direction of E_x) are parallel to the global x-axis. 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 Ratio	ν_{yz}	0.400	—
			ν_{xz}	0.050	—
			ν_{xy}	0.050	—
		Shear Modulus	G_{yz}	200.000	MPa
			$G_{xz} = G_{xy}$	700.000	MPa
		Tensile Plastic Strength	$f_{t,x}$	35.000	MPa
			$f_{t,y}$	3.404	MPa
			$f_{t,z}$	1.500	MPa
		Compressive Plastic Strength	$f_{c,x}$	20.000	MPa
			$f_{c,y}$	1.531	MPa
			$f_{c,z}$	3.500	MPa
		Shear Plastic Strength	$f_{v,xz} = f_{v,xy}$	2.700	MPa
			$f_{v,yz}$	1.000	MPa
Geometry	Timber	Length	L	9.000	m
		Thickness	t	0.120	m
		Height	h	0.600	m
		Loaded Surface Length	ΔL	0.200	m
	Steel plates	Width	w	0.010	m
Load		Pressure	p	3.250	MPa

Small deformations are considered and the self-weight is neglected in this example. Determine following quantities:

- The maximum deflection $u_{z,max}$
- The strain ε_x^p, ε_z^p and γ_{xz} at the test point 1
- The stress σ_x, σ_z and τ_{xz} at the test point 2

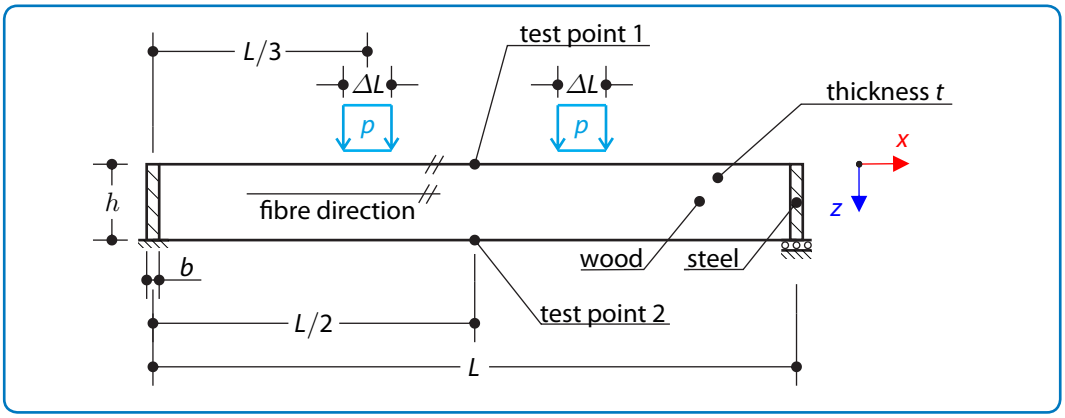

Figure 1: Problem sketch

Analytical Solution

Analytical solution is not available for this example.

RFEM 5 Settings

- Modeled in RFEM 5.06.1176
- The element size is $l_{FE} = 0.060$ m
- Geometrically linear analysis is considered
- The number of increments is 10
- Considering symmetry, only one half of the construction is modeled in the direction of the y-axis

Results

Structure File	Entity	Material model
0012.01	Solid	Orthotropic Plastic 3D
0012.02	Plate	Orthotropic Plastic 2D

Linear Elasticity Results: $u_{z,max}$ [mm]	
RFEM 5 (Solid)	RFEM 5 (Plate)
81.892	81.909

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 [-]
101.36	105.722	1.043	101.853	1.005

Test Point 1 $\left[\frac{l_x}{2}, 0, 0\right]$					
	ANSYS 15 (SOLID45 with extra shape functions, 3D)*	RFEM 5 (Orthotropic Plastic 3D)	Ratio	RFEM 5 (Orthotropic Plastic 2D)	Ratio
ε_x^p [-]	$-0.194 \cdot 10^{-2}$	$-0.199 \cdot 10^{-2}$	1.026	$-0.176 \cdot 10^{-2}$	0.907
ε_z^p [-]	$0.938 \cdot 10^{-2}$	$0.938 \cdot 10^{-2}$	1.000	0.000	—
γ_{xz}^p [-]	0.000	0.000	—	0.000	—

Test Point 2 $\left[\frac{l_x}{2}, 0, h\right]$					
	ANSYS 15 (SOLID45 with extra shape functions, 3D)*	RFEM 5 (Orthotropic Plastic 3D)	Ratio	RFEM 5 (Orthotropic Plastic 2D)	Ratio
σ_x [MPa]	35.043	36.298	1.036	33.061	0.943
σ_z [MPa]	0.005	−0.022	—	0.000	—
τ_{xz} [MPa]	0.000	0.000	—	0.000	—

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