

Laminated Strip under three-point bending

REFERENCE Composite Benchmarks, Ref . R0031, Issue 2, NAFEMS, Glasgow, 2001

MODEL FILENAME Laminated strip explicit.nfx

Figure 1 shows a laminated strip with [0/90/0/90/0/90/0] layup subjected to three-point bending. Nonlinear explicit transient dynamic analysis is carried out using layered shell elements to obtain the steady-state response of the laminate. During the analysis, the inertial effects are damped out to obtain steady state responses. The resulting vertical displacement and the inplane bending stress are obtained at the point E. These values are compared the reference values. The corner stress is underestimated with reduced integration elements since stress is only computed at the center of these elements.

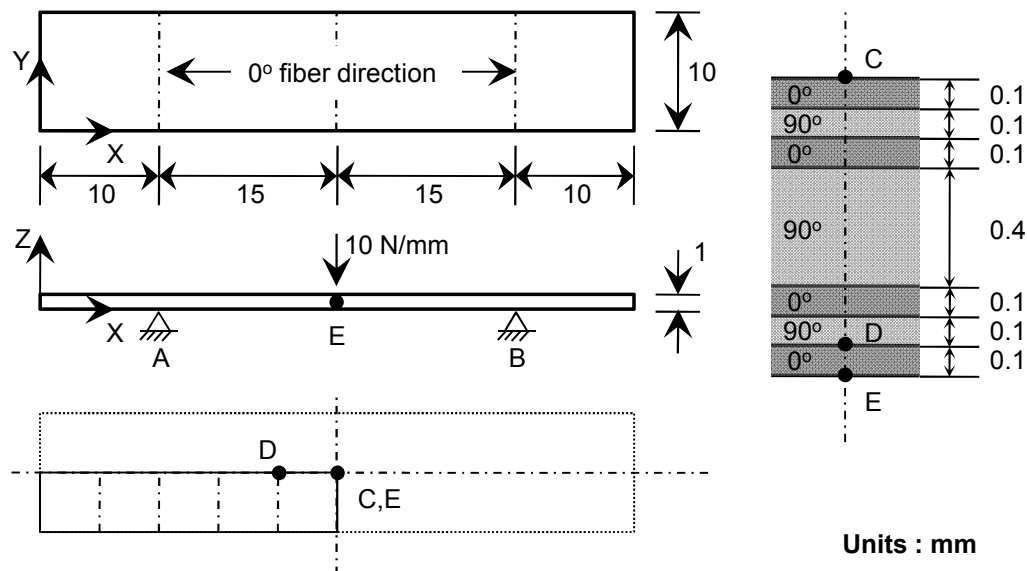


Figure 1. Laminated strip model

Material data	Young's modulus	$E_1 = 100 \text{ GPa}, E_2 = E_3 = 5 \text{ GPa}$
	Shear modulus	$G_{12} = 3 \text{ GPa}, G_{13} = G_{23} = 2 \text{ GPa}$
	Poisson's ratio	$\nu_{12} = \nu_{13} = 0.4, \nu_{23} = 0.3$
	Density	$\rho = 0.1 \text{ kg/mm}^3$
	Mass proportional damping	$\alpha = 8.4 \text{ sec}^{-1}$
	Stiffness proportional damping	$\beta = 1.0 \times 10^{-4} \text{ sec}$

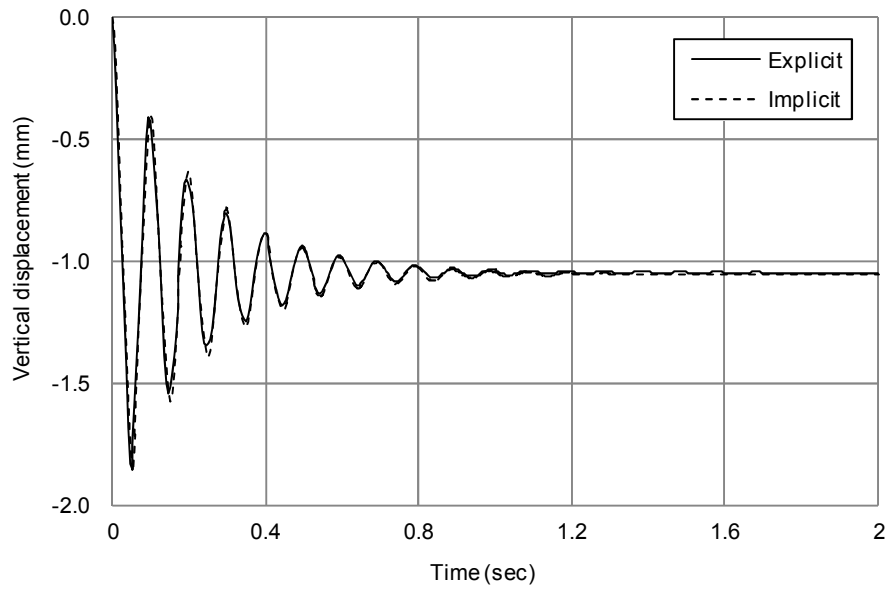


Figure 2. Time history of the vertical displacement at point E

Table 1. Bending stress σ_{11} and Z deflection u_Z at point E obtained using layered shell elements

	σ_{11}^E [MPa]	u_Z^E [mm]
Reference	683.9	-1.06
Analysis type		
Explicit transient	622.8*	-1.05

* obtained using layered quadrilateral elements with reduced integration