Laminated Strip under three-point bending

REFERENCE	Composite Benchmarks, Ref . R0031, Issue 2, NAFEMS, Glasgow, 2001
MODEL FILENAME	Laminated strip implicit.nfx

Figure 1 shows a laminated strip with [0/90/0/90/0/90/0] layup subjected to three-point bending. Nonlinear implicit 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.

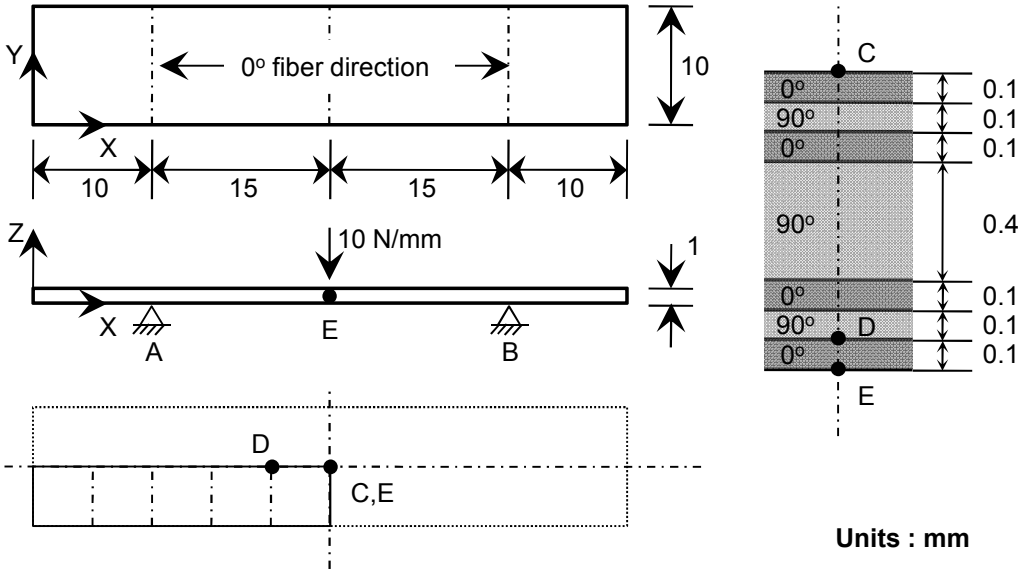

Figure 1. Laminated strip model

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

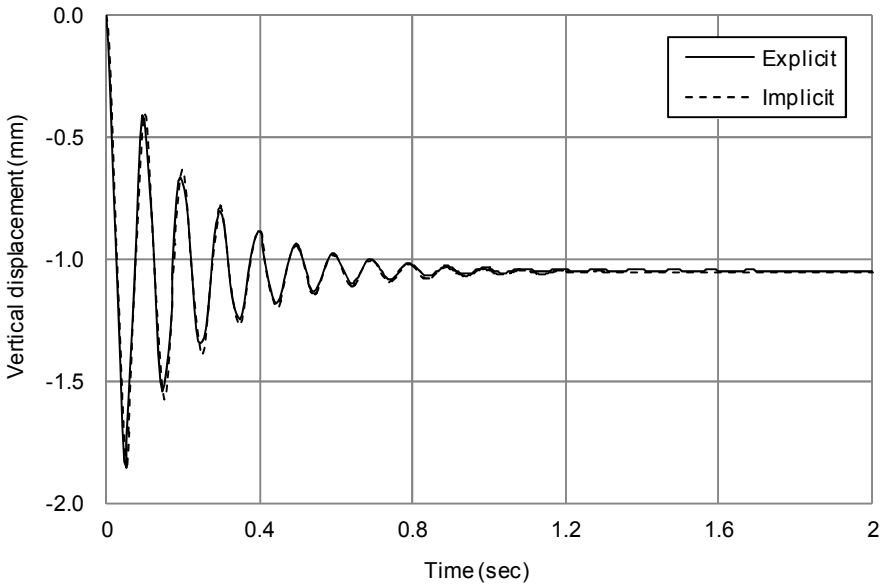

Figure 2. Time history of the vertical displacement at point E

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		
Implicit transient	**673.8 (622.9*)**	**-1.05**

* obtained using layered quadrilateral elements with reduced integration