The Effect of In-Plane Deformations on the Nonlinear Dynamic Response of Laminated Plates

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In-plane deformations may be important when the plates undergo large deflections as a result of applied loading. There are many studies in the literature on the large deflection of laminated plates subjected to the blast loading [1-6]. In some of them, the in-plane deformations are not taken into account [2]. It could be important to investigate the effect of in-plane deformations. In this study, the strain time histories obtained from large deflection analysis of laminated plates with and without in-plane deformations are compared. The effect of the magnitude of the blast load, the thickness of the plate and boundary conditions on the in-plane deformations is investigated. The clamped and simply supported boundary conditions are considered.

In-plane stiffness and inertia effects are considered when formulating the dynamic response of the laminated composite plate subjected to the blast loading. The geometric nonlinearity effects are also taken into account by using the von Kármán large deflection theory of thin plates. Transverse shear stresses are ignored. The equations of motion for the plate are derived by the use of the virtual work principle. Approximate solution functions are assumed for the space domain and substituted into the equations of motion. Then, the Galerkin method is used to obtain the nonlinear differential equations in the time domain. A FORTRAN program was written to solve the nonlinear coupled equations of motion. The finite difference method is applied to solve the system of coupled nonlinear equations. The strain-time history obtained from the large deflection analysis with in-plane deformations taken into account (LDWI) is shown in Figure 1. To understand the effect of in-plane deformations, only the geometric nonlinearity effects are taken into account by using the von Kármán large deflection theory.
of thin plates. In-plane stiffness, inertia and transverse shear stresses are ignored. The strain-time history obtained from the large deflection analysis without taking the in-plane deformations into account (LD) is also shown in Figure 1. The difference between them is that because the in-plane effects play a role when the deformations are large. The in-plane strain-time history (LDI) is also shown in Figure 1. It is clearly shown that the LDI is almost the difference between the LD and LDWI. However, it is not exactly the case. LDWI without LDI is also given in the same figure (LDC). This indicates that there is still a difference between LD and LDC. This difference decreased when the magnitude of the load is decreased.

References