Numerical modeling of the low-velocity impact of composite structures using the peridynamics

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ABSTRACT

In this investigation, a low-velocity impact of multilayered structures based on a nonlocal Peridynamics is presented. The Peridynamics [1] has its interests compared to the classical theory and other nonlocal theories in that it does not involve spatial derivatives of the displacement field. The Peridynamics is rather based on the integral equation instead of differential equations to handle discontinuities and other singularities in the displacements and stresses. The originality of the present investigation consists in reformulating the Peridynamics for multilayered beams and shells by separating the bending and shear effects.

The proposed Peridynamics model, presented in this investigation is based on a reduced and selective integration approach allowing at the same time avoiding locking phenomenon and convenient for explicit time integration algorithms due to their small CPU time consumption. Hence, the proposed methodology effectively predicts failure in complex structures under impact loading. While matrix failure, fiber fracture, and delamination are essential to the complex nature of composite structures, consequently it appears to be essential that the inhomogeneous nature of the composites must be retained in the analysis in order to predict the correct failure.

In this work, the numerical application chosen to illustrate by the Peridynamic model is the one reported in Qian and Swanson [2]. It consists of central impact of a $[0/90/0/90/0]_s$ T300/934 carbon-epoxy plate by a rigid ball. The composite structure has been modeled using particles discretization of Figure 1 and the impact response of the structure is examined (see Figure 1). The obtained numerical results are compared with some reference solutions [2-4]. It has been shown through the present investigation, that the Peridynamic model adapted for the low-velocity impact of thin composite structures may constitute a real alternative to the finite element method.

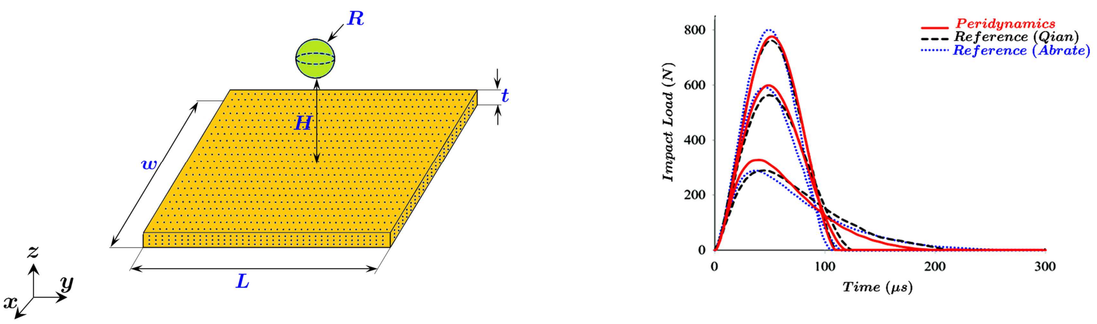

Figure 1: Impact of composite plate using the peridynamics

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