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LOW-VELOCITY IMPACT RESPONSE OF COMPOSITE LAMINATES CONSIDERING HIGHER-ORDER SHEAR DEFORMATION AND LARGE DEFLECTION

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SUMMARY

Low-velocity impact responses of composite laminates are investigated analytically and experimentally. In analytical research, the finite element analyses based on various plate theories and three-dimensional thoeory are performed. For experimental research, a drop weight type impact test sytem is used. In geometrical non-linear analysis, a displacement field considering higher-order shear deformation and large deflection of the laminate is assumed and the finite element formulation is derived. The modified Hertzian contact law is incorporated into the finite element program to evaluate contact force. Numerical results including impact force histories, deflections, dynamic strains in the laminate from the impact response analysis are presented and compared with the experimental results from impact test. The results of the investigation indicate that higher-order shear deformation and large deflection effects should be considered to accurately describe the low-velocity impact response including interlaminar shear stress of the laminate.

1. INTRODUCTION

Advanced composite materials such as graphite/epoxy have been successfully employed as structural materials in space vehicles, aircrafts, and missiles. However, their resistance to impact loading has become a major concern and been the focus of study for the last two decades. 'Low-velocity impact' (that is, low-energy impact) is considered potentially dangerous mainly because the damage might remain undetected and cause significant reductions in the strength of the material.

Hence, the subject of low-velocity impact in composite laminates has been investigated by many researchers. However, because of the complicated failure mechanism in composite materials, there are few analytical methods available which can predict the impact damage in composite laminates.[1] Recently, it has been reported that intraply matrix cracks are the initial impact damage mode and delamination is induced from these matrix cracks.[2–4] Also, it has been reported that the interlaminar shear stress and the in-plane tensile stress in the direction transverse to the fibre orientation are major stress components that could contribute to initial matrix cracking leading to delamination[2]. Therefore, in order to analyse the impact damage of composite laminates, the stress components including the transverse shear stress must be analysed accurately.

Many analytical methods for describing the impact response of composite laminates have been reported[5–18] in addition to investigations using the finite element method selectively cited here. Sun and co-worker used a first-order shear deformation theory (FSDT). It is well-known that FSDT assumes that the transverse shear strain be constant, which is less

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