

by numerical simulations. Firstly, the modified Johnson-Cook constitutive relation and the Gruneisen equation of state which are valid for metals subjected to impact for large strains, high strain rates and high temperatures are implemented in ABAQUS/Explicit as a user-defined material model by means of a subroutine (VUMAT). Whereafter, numerical simulations are conducted on the perforation of 12 mm thick Weldox460E steel plates struck normally by conical-nosed projectiles and 6 mm and 12 mm thick Weldox460E steel plates struck normally by flat-ended projectiles, the cone angles of which are equal to 180 degree as a special case of conical-nosed projectiles. Comparisons of the numerical results and the experiments in terms of the patterns of targets after full perforation and the residual velocities show that the finite element models developed here are reliable. Finally, based on the verified finite element model, numerical simulations are performed on the perforation of 6 mm thick Weldox460E steel plates struck normally by conical-nosed projectiles with various cone angles, and the effects of various cone angles on the failure modes of metal plates and the energies absorbed for perforation are discussed. It is found that projectile cone angle has significant effect on the perforation modes of 6mm thick Weldox460E steel plates and that for smaller cone angles plates fail by ductile hole enlargement, for medium cone angles plates fail by petalling and for larger cone angles plates fail by discing or plugging. The energy dissipated by discing is maximum, and one by plugging is minimum.

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S24-023

Dynamic fracture of advanced ceramics under impact loading conditions using a miniaturized Kolsky bar

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Advanced ceramic materials are frequently used in the machining of hardened steels, aerospace alloys and other abrasive materials. While these materials have many superior properties such as high hardness and abrasive resistance they are still prone to premature failure due to fracture. Accurate fracture properties of such materials are scarce, especially in the dynamic regime. The current work presents a novel combined experimental-numerical approach to determine dynamic fracture behavior. In recent years, much attention has been given to the study of dynamic behavior of materials under stress-wave loading. Experimentation with a modified Kolsky bar and a concurrent numerical investigation using the finite volume method was used in this study. The inherent difficulties in producing large amounts of advanced ceramic means that experiments must be carried out using very small samples. As a result the apparatus has been miniaturised to accommodate such specimen dimensions. The incident and reflected wave histories obtained experimentally in conjunction with the time to fracture of the specimen predicted numerically are used to determine fracture toughness at a number of loading rates. Presented is a novel and simple test method to determine fracture properties of advanced ceramics using a miniaturised Kolsky bar. Results indicate a change in fracture toughness at increased rates of loading. This may be due to the complicated underlying microstructure of the materials under investigation, which behave differently under varying loading rates.

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S24-024

Dynamic behavior of crumb rubber concrete subjected to repeated impacts

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An experimental investigation on the dynamic mechanical behavior of the crumb rubber concrete (CRC) with crumb rubber contents varying from 0% to 20% (equal volume of fine aggregate replacement) subjected to repeated impacts was conducted using split-Hopkinson pressure bar

(SHPB). The influences of rubber contents on dynamic properties of CRC subjected to repeated impacts were explored. The test results show that the impact resistance times of CRC increases first and then decreases with the increase of rubber contents, whereas the static compressive strength of CRC decreases with the increase of rubber contents. The capability of energy absorption of CRC under impact loading is higher than that of normal concrete (NC). The incorporation of rubber enhanced the toughness of CRC significantly and the impact resistance of CRC is greatly increased.

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Behavior of interface crack in layered structure under actions of both stress wave and residual stress

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It has been reported that the residual stress would influence the stress pattern of layered structure subjected to impact loading. In this article, the propagation characteristic of stress wave impinging at the interface between initially stressed film and substrate is analyzed to reveal the effect of residual stress on the fracture behavior of such layered structure. In particular, the response of interface crack to both stress wave and residual stress is investigated based on an axis-symmetric model including a centric coin-shape interface crack. The dispersion of the stress wave and the dynamic stress singularity around the interface crack tip are discussed. It is revealed that the inclination of interface to the loading surface will develop great shear stress wave at the interface even when the initial stress pulse is purely compressive. Furthermore, the arising of interface shear stress would change the mixture mode of the interface crack and lead to partially relaxation of the residual stress, of which the principal directions are always parallel to the interface. The results also indicate that the residual stress would be partially changed into kinetic energy and thereby influence the dynamic behavior of the interface crack.

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S24-026

Experimental and numerical investigation of fibre-metal laminates during low-velocity impact loading

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Fibre-metal laminates (FMLs) that consists of three layers of 2024-T3 aluminium alloy sheets 0.254 mm in thickness and two layers of [0/90/90/0] glass/epoxy composite with each prepreg 0.15 mm in thickness were studied in this work. The specimens were cut into a size of 100×150 mm². Both experimental and numerical simulations were performed successfully. According to ASTM-D-7136, low-velocity impact tests were performed on FMLs, using an instrumented falling weight machine. For comparison purposes, similar tests were set up and were carried out on monolithic 2024-T3 sheets of 2 mm in thickness. Tests were performed in the different energies ranging from BVID to complete penetration. And then residual displacement, indentation depth, the crack length of back surface and after impact were compared and analyzed. Force-displacement curves were compared. It is shown that the relation of them kept the same during loading for FMLs even after penetration, which means that the same equation can be used to relate the force with displacement; while the relation is not the same for unloading, but the tendency can be expressed by residual displacement. For samples were completely impacted through, impact energy of the laminates is 40% higher than Al alloy; for the same energy, crack length on the back surface of laminates is 30%–50% shorter than in the Al alloy panel. ABAQUS/Explicit was used to simulate dynamic response and damage evolution of FMLs during