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Fracture Behavior of Periodic Porous Structures by Phase Field Method

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ABSTRACT

Intensive dynamic loadings are the main threats to the structural damage of protective structures and inner equipment, which has attracted a lot of attention in the field of advance impulsive resistance. Nanofluidic liquid foam (NLF) has become a novel and efficient energy absorption system due to its reusable energy absorption, ultra-high load transfer, and high energy absorption ratio. In order to solve the current problem that the energy absorption mechanism of NLF is still unclear, this paper conducted a systematic experimental study on the dynamic compression and energy absorption behaviours of NLF. The quasi-static cyclic compression experiments with different liquid types and loading rates were carried out, which revealing the effect of solid-liquid properties on the infiltration pressure and clarifying the strain rate insensitivity of NLF. Also, the main parameter properties affecting the energy absorption density and the repeatable usage rate of NLF are obtained. Moreover, the dynamic impact experiments were carried out by a separated Hopkinson pressure bar (SHPB) experimental setup, the influence laws of different loading rates on the macroscopic mechanical response and microscopic infiltration behavior of NLF are discussed. It is found that the mechanical properties of NLF materials under dynamic impact, although still based on their nano-scale solid-liquid infiltration behaviour, are not exactly the same as the influence mechanism under quasi-static conditions. The results also indicate that gas molecules have a similarly significant effect on the liquid infiltration behavior and energy absorption efficiency of the NLF under high strain rate impacts. The research fills the lack of study on dynamic infiltration and energy absorption characteristics, and provides theoretical reference for the research and development of various nanofluid systems.

KEYWORDS

Nanofluidic liquid foam; energy absorption; strain ratio effect; infiltration and exfiltration

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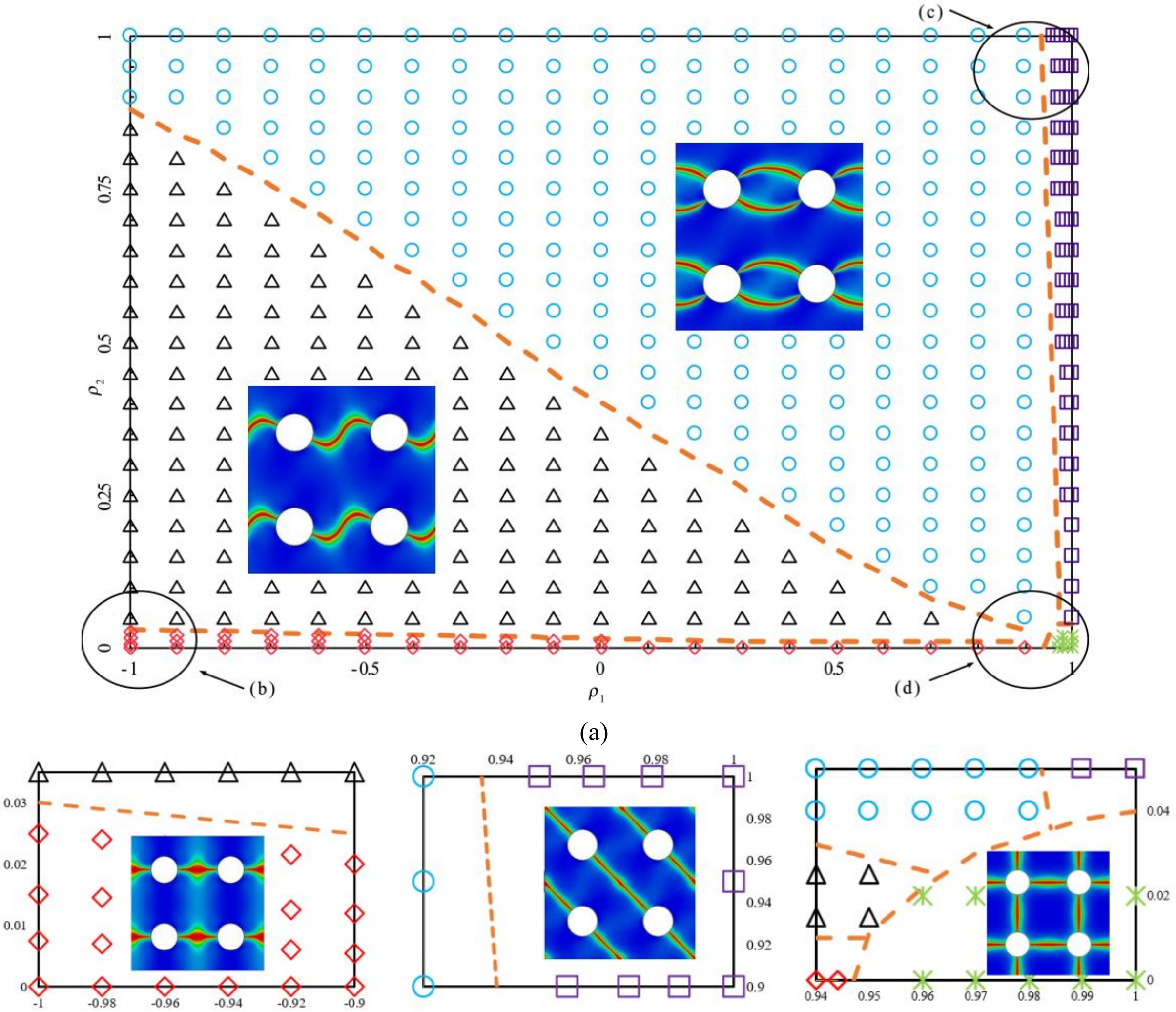

(a) (b) (c) (d)

The phase diagram of crack propagation mode for periodic porous structure under different multiaxial proportional loading is illustrated in Fig (a). The phase diagram is divided into five regions in total, and the yellow dotted lines are used to represent the phase boundary of the fracture mode transition. Fig (b), (c) and (d) are partial enlargements of the phase diagram, respectively. $\rho_1 = P_{11} / P_{22}$ and $\rho_2 = P_{12} / P_{22}$ are biaxial stress ratio and shear stress ratio, respectively. The crack propagation modes of periodic porous structures are mainly S-type and double-arc type, and the phase boundary of these two modes is approximately linear. When $\rho_2 \leq 0.03$, the crack propagation mode changes from S-type to horizontal type. When $\rho_1 \geq 0.94$, the crack propagation mode changes from double arc to oblique type. In a very small region where $\rho_1 \geq 0.95$ and $\rho_2 \leq 0.04$, the orthogonal cross-type crack pattern can be observed.

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Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

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