Department of Mechanical and Aerospace Engineering

Analysis of PVC Foam and Carbon Nanofiber Syntactic Foam

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Abstract

Properties of materials are known to be dependent on the loading rate. Composite materials are now widely used in daily life and they undergo high loading rate deformations in many current applications. However, their high strain rate properties and failure mechanisms are not well understood. The present research uses in-house developed advanced instrumentation to develop such knowledge.

Objective

- PVC foams: marine structural applications
- Strain rate sensitivity of PVC foams
- Syntactic foams: Porous composite materials
- Nanoscale reinforcement of syntactic foams
- Strain rate sensitivity of the carbon nanofiber reinforced syntactic foams
- Test methods, instrumentations, and protocols

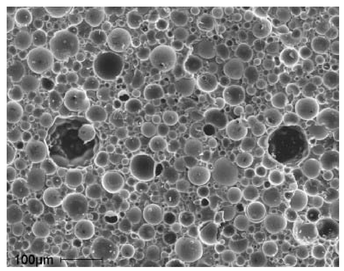
PVC Foam

- Lightweight
- Chemically-resistant
- Does not absorb water
- Marine applications
- Forms, cuts and glues easily
- Excellent insulator

Microscopic image of PVC foam

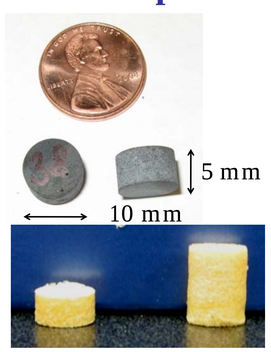
Syntactic Foam

- Hollow glass microballoons mixed with an epoxy
- High elastic modulus, strength, and energy absorption
- Low moisture absorption
- High strength, lightweight, and energy absorption lead syntactic foams to applications in aerospace and marine vehicles



Microscopic image of syntactic foam with glass microballoons

Test Samples



1% Carbon Nanofiber Syntactic Foam

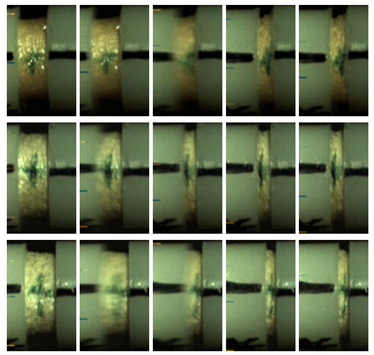
- For this study, carbon nanofibers (CNF) were added to the syntactic foam mixture during production
- CNFs have high strength and modulus
- This study will analyze whether the addition of CNF will improve the strength of syntactic foams

Specimens

- Four types of PVC Foam were tested:
  - HP-250, 200, 100, 60
- Four types of syntactic foam were tested:
  - CNF 220-30, 220-50, 460-30, 460-50
- Two Additional samples were tested without microballoons:
  - A sample of 1% CNF with epoxy, and a sample of only hardened epoxy

Instrumentation

- Compression experiments were carried out using both quasi-static and dynamic systems to characterize the materials at both low and high strain rates
- Instron 4469 servo-hydraulic machine used for quasi-static testing at lower strain rates
- Split-Hopkinson pressure bar (SHPB)system used for dynamic testing of materials at significantly higher strain rates
- High-speed camera used for capturing SHPB images



Comparison of 3 PVC foam types at a strain rate of slightly less than 2000s^{-1}
Images taken at 6269 frames per second

Instron 4469 quasi-static system

SHPB dynamic system with high speed camera in place

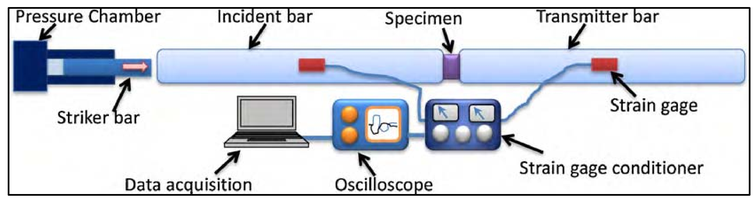
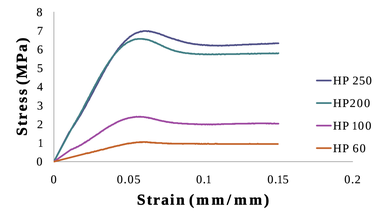


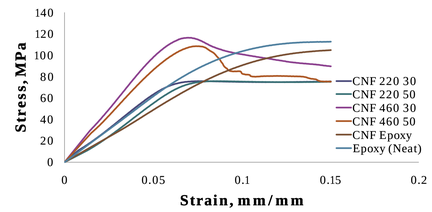
Diagram of Split-Hopkinson pressure bar system

Static Results

PVC Foam

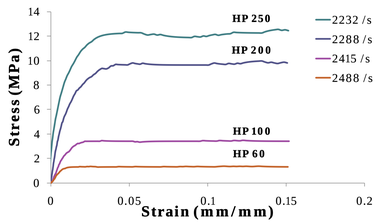


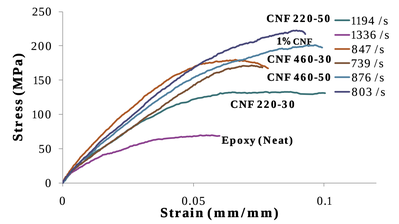
Syntactic Foam



Static testing of various samples at a rate of 1 mm/min.

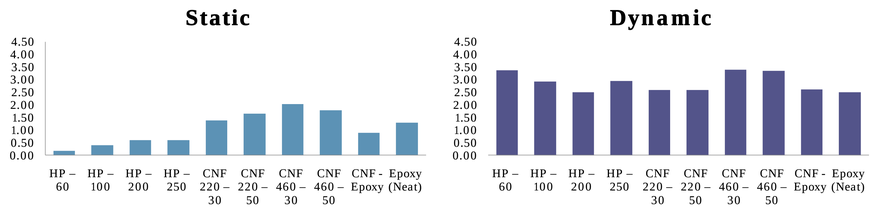
Dynamic Results



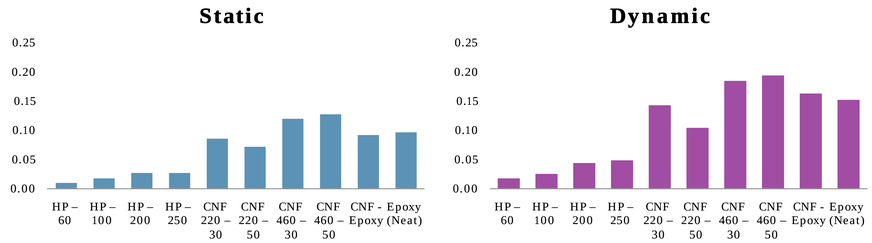


Dynamic testing of various samples at high strain rates (≈10^3).

Compressive Modulus/Density (MPa/kg/m^3)



Peak Strength/Density (MPa/kg/m^3)



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