CHARACTERIZATION OF A FOAM CORE UNDER SLAMMING LOADING ON COMPOSITE SANDWICH HULLS

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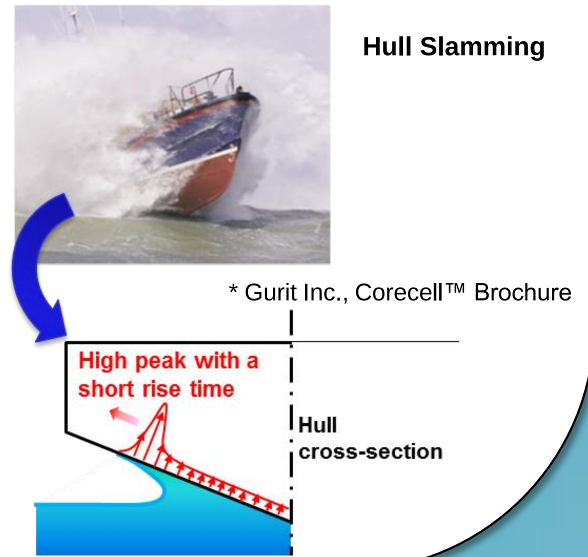
INTRODUCTION

- Advanced composite sandwich structure is widely used as the primary hull structure of high-speed marine vessels.
  - ✧ Structural sandwich composites with foam cores have proven advantages.
    - Improved stiffness / strength
    - Lightest structural material form
    - Highest specific properties
- Future trend in marine industry requires that the reliability and durability have to be enhanced so that composite sandwich hulls are utilized more safely and effectively.
- Slamming is a crucial concern in the structural design of a high-speed marine craft.
  - ✧ High pressure peak causes local material or structural degradation.
  - ✧ High frequencies of slamming events increase fatigue failure.



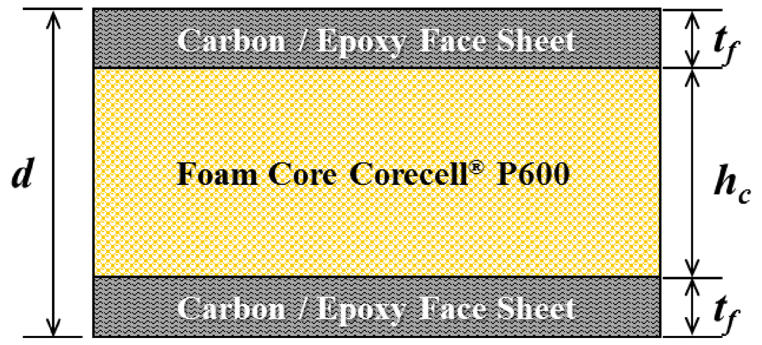
RESEARCH QUESTIONS AND PROPOSED APPROACHES

- Material Behavior of Composite Sandwiches due to Slamming
  - ✧ Focus on the characterization of the dominant foam core by lab-scale testing considering multiple slam events.
  - ✧ Proposed method approach is to utilize **Dynamic Mechanical Analysis (DMA).**
- Prediction of Slamming Loads and Structural Response
  - ✧ Focus on the CFD and FEA modeling of a composite sandwich structure incorporating the foam core property subjected to wave slamming-loads.
- Marine Design
  - ✧ Estimate the long-term effect and degradation of composite sandwich hull material due to slamming.

BASELINE SANDWICH CONSTRUCTION

Carbon/Epoxy Face Sheets

- Eight (8) layers of 4x4 Twill Carbon Fabric
- t_f= 2.4 mm [0.1”]
- ρ_f =1478 kg/m^3



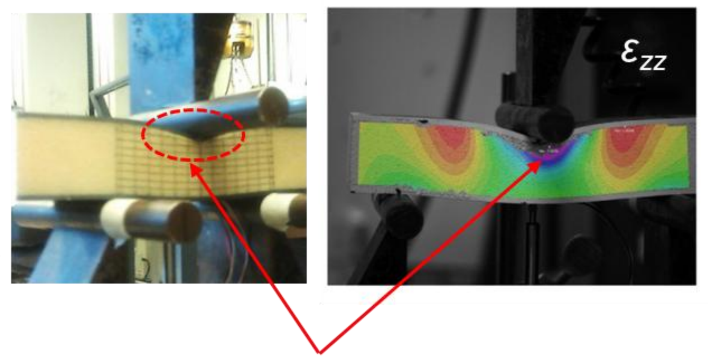
Foam Core

- Styrene Acrylonitrile (SAN) Polymer
- h_c= 38 mm [1.5”]
- ρ_c=122 kg/m^3

Processing

- ✧ Out of Autoclave (OOA): Prepreg Vacuum Bagging / Oven Cure
  - Quasi-isotropic Layup: $[(0/90)/(+45/-45)]_4$/core/$[(-45/+45)/(90/0)]_4$
  - No Adhesive Interface
  - Debulked at RT for 12 hrs
  - Cured at 65°C [150°F] for 16 hrs

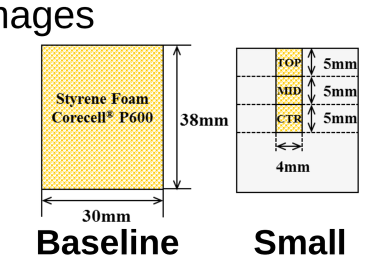
Typical Failure under Three Point Bending



Core crushing / local compressive failure

BENCHMARK TESTING OF FOAM CORE

- Verification in Static Tests
  - Mechanical properties and micro damages
  - Specimen dimension sensitivity
  - Homogeneity through the thickness

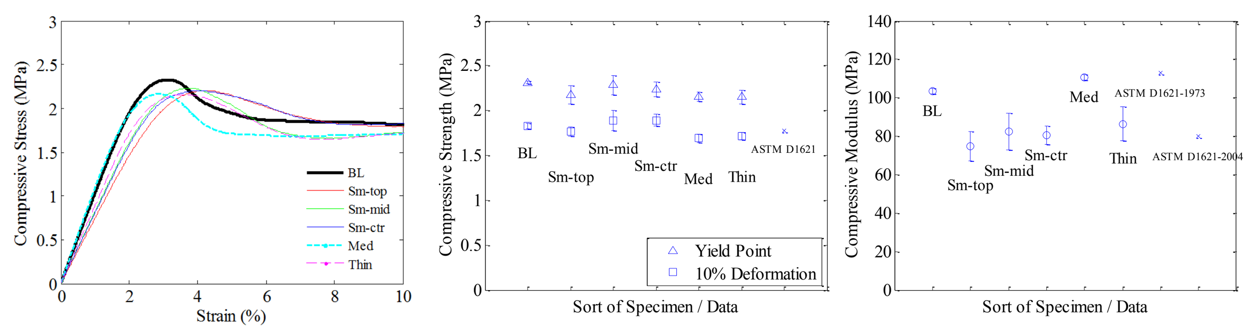


- Test Specimen
  - Cuboid, square in cross section, different in dimensions.

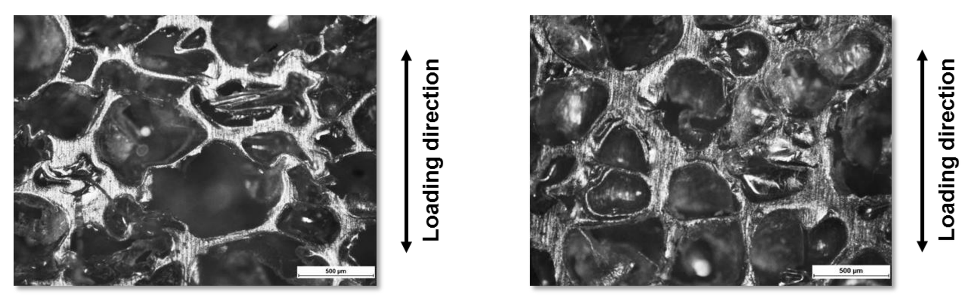
	Baseline	Small (DMA-type)	Medium	Thin
W, T	30 mm	4 mm	15 mm	30 mm
H	38 mm	5 mm	19 mm	5 mm
Slenderness Ratio	4.40	4.33	4.39	0.58
Strain Rate	0.1	0.1	0.1	0.1

RESULTS OF STATIC COMPRESSIVE TESTS

- Comparison of Static Mechanical Properties



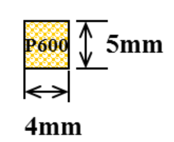
- Microscopic Failure

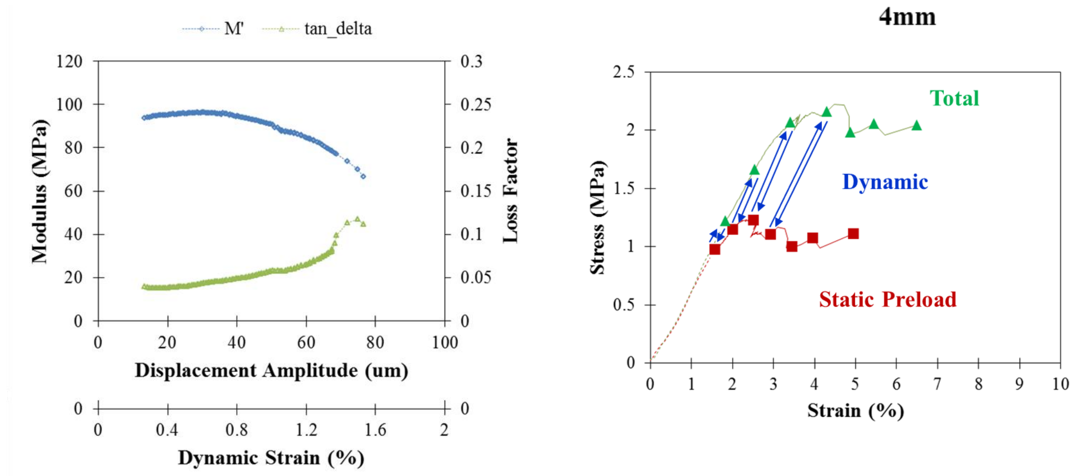


Baseline Small

PRELIMINARY DMA EXPERIMENTS

- Dynamic Strain Sweep Testing
  - ✧ Increase the displacement amplitude until a foam crushes.
  - ✧ At ambient RT with 1 Hz
  - ✧ Small (DMA-type) specimens





SUMMARY

- This research proposes utilizing DMA to investigate the fatigue property of a foam core under slamming events.
- The study uses the prospective sandwich construction with high impact tolerant styrene foam core and OOA prepreg process.
- Static compression tests confirms small DMA-type specimens represent the consistent properties to the baseline foam material.

ACKNOWLEDGEMENTS

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