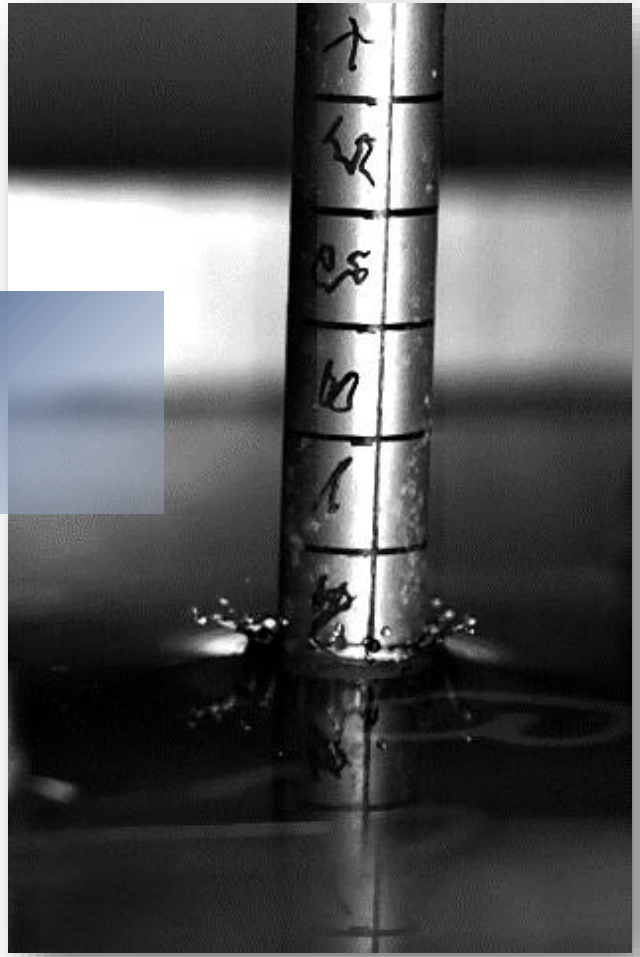

ICCM23, 30th July – 4th August 2023, Belfast

A NEW METHOD OF UNDERWATER COMPOSITE IMPACT TESTING

Authors: Rowan L. Caldwell[1], Matthew J. Donough[1], Gleny T. Chirima[2], Alban Robin[3], Andrew W. Phillips[2], Nigel A. St John[2], B. Gangadhara Prusty[1]

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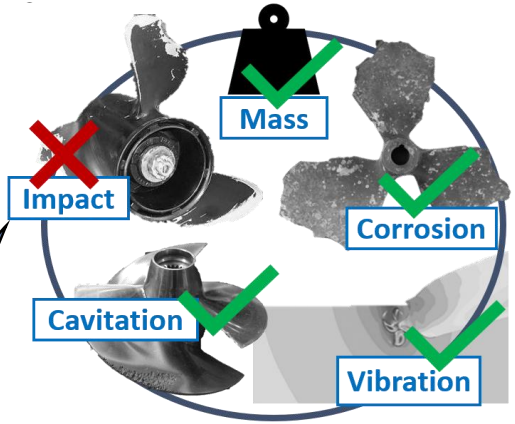
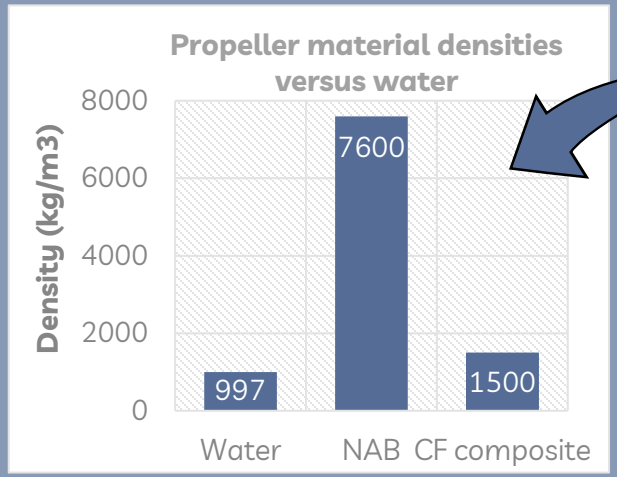
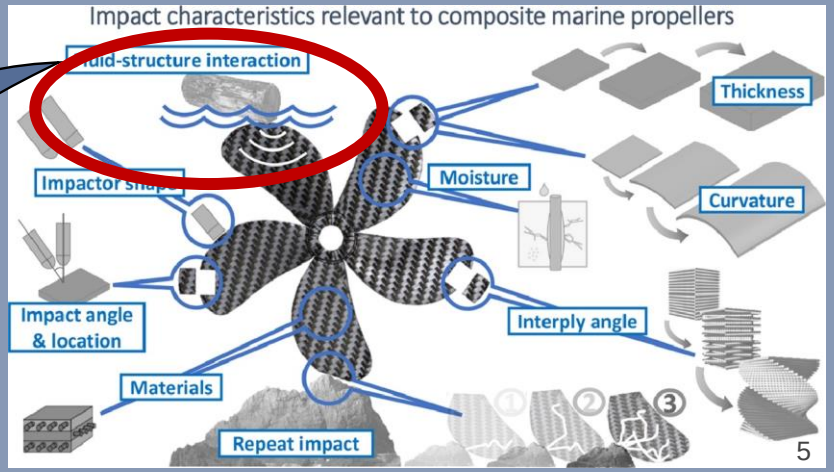
DURABILITY OF COMPOSITE PROPELLERS

This work was conducted as part of a UNSW PhD degree in association with the Durability of Composite Propellers project, an international joint research effort between UNSW AMAC CRC (AU), DSTG (AU), IFREMER (FR) and DGA (FR).


Mass
Impact
Corrosion
Cavitation
Vibration


Propeller material densities versus water
Density (kg/m3)
8000
6000
4000
2000
0
997
7600
1500
Water
NAB
CF composite


Impact characteristics relevant to composite marine propellers
Fluid-structure interaction
Impactor shape
Impact angle & location
Materials
Repeat impact
Thickness
Moisture
Curvature
Interply angle
5

WHY?

WHY?

Water decreases damage

HAMPSON, P.R. AND MOATAMEDI, M., 2010

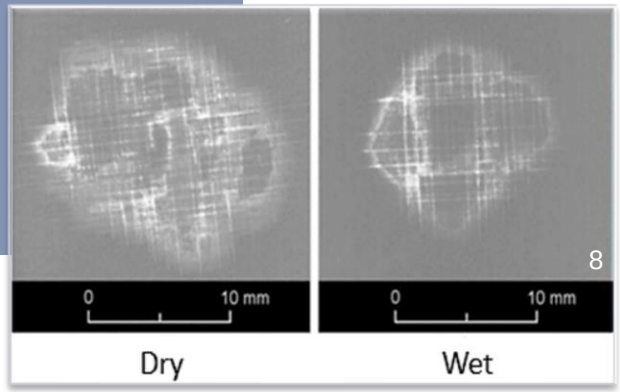
Damage area decreased for wet impacts due to reduced peak impact force.

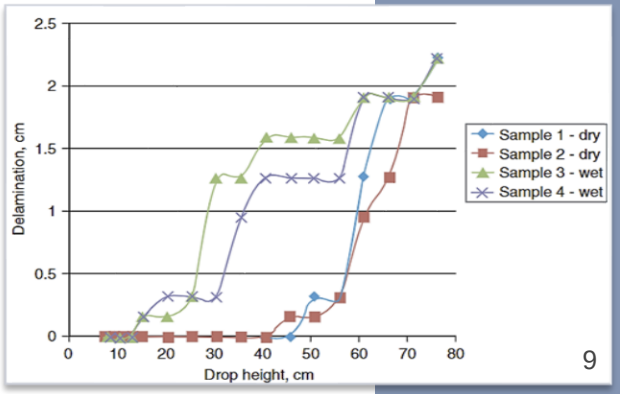
≠

KWON, Y. AND CONNER, R., 2012

Damage area increased for wet impacts due to increased peak impact force

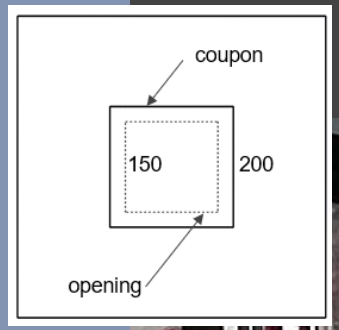
Water increases damage

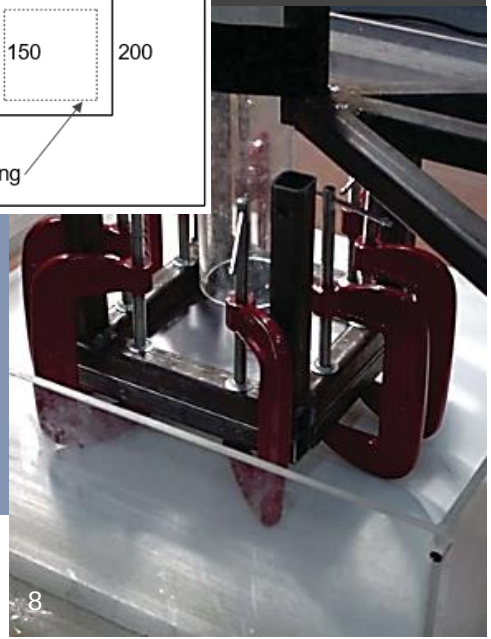




WHY?

HAMPSON, P.R. AND MOATAMEDI, M., 2010





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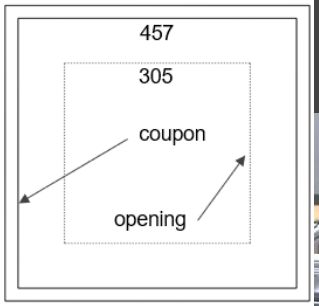
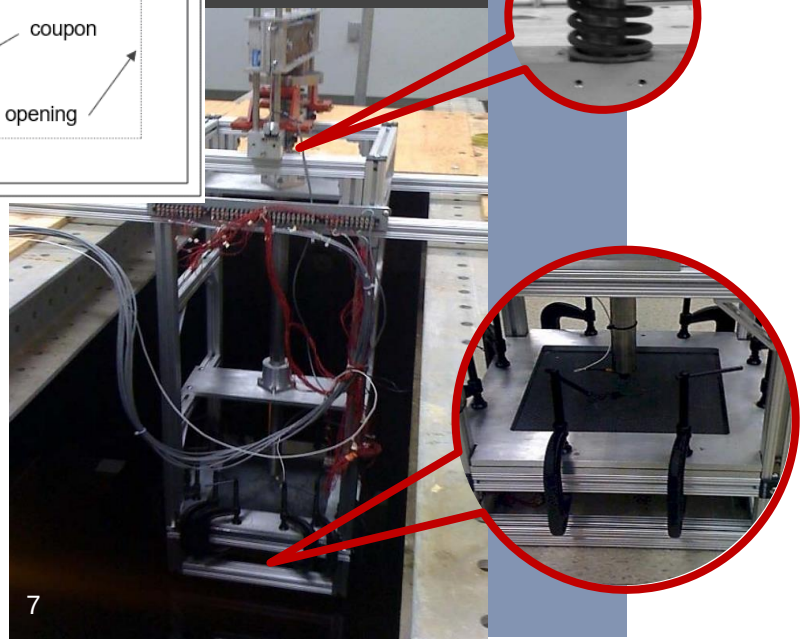
KWON, Y. AND CONNER, R., 2012



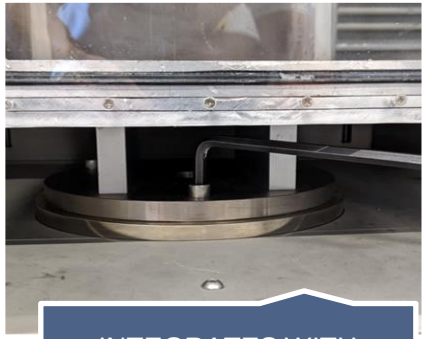


7

All dimensions in mm

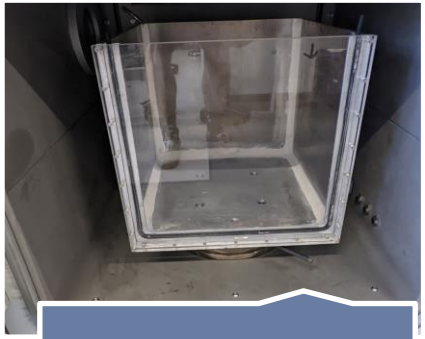
LABORATORY-SCALE, INSTRON INTEGRATED, UNDERWATER IMPACT SYSTEM, METHODOLOGY AND RESULTS

WHAT?

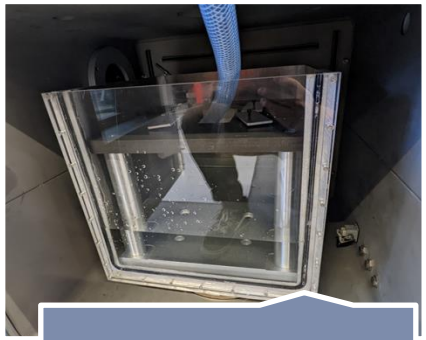


INTEGRATES WITH INSTRON

SEALED PERSPEX VIEWING WINDOW



INSTALLATION = 20 MIN

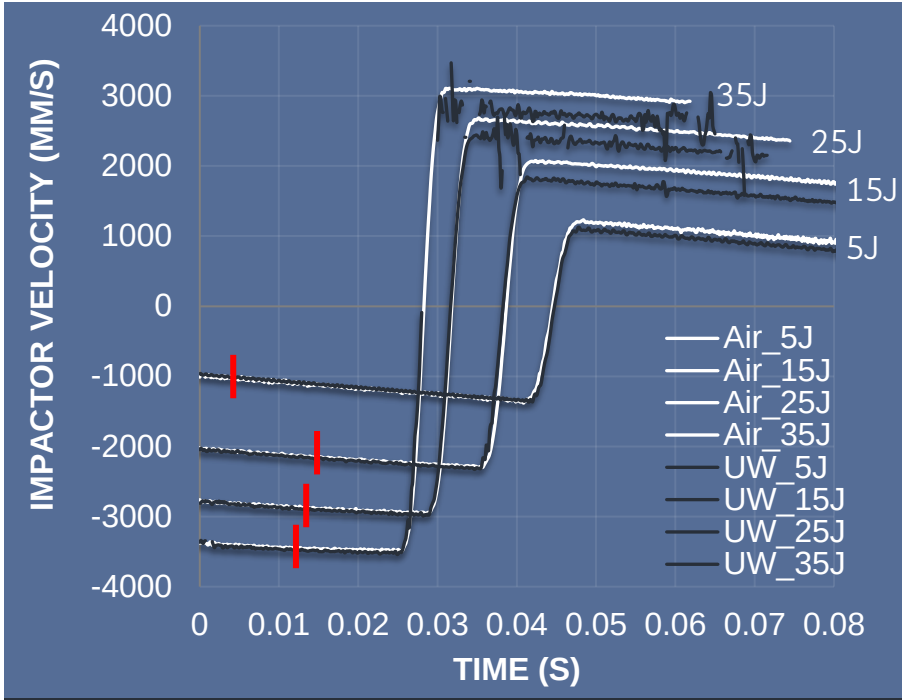


TANK FILING = 5 MIN

COUPON EXCHANGE = 30 SEC

TANK EMPTY = 5 MIN

WHAT?



- Red marks indicate the time of water entry.
- No difference in dry (air) and wet (UW) velocity profiles during water entry or just prior to coupon impact.
- Energy absorption of water damping increased with impact energy

HOW?

Designation: D7136/D7136M – 15

Standard Test Method for
Measuring the Damage Resistance of a Fiber-Reinforced Polymer Matrix Composite to a Drop-Weight Impact Event[1]

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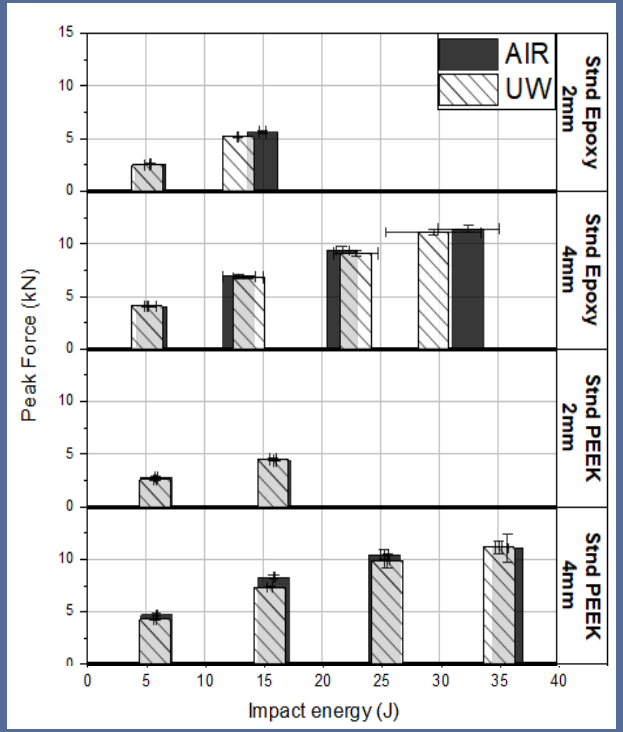
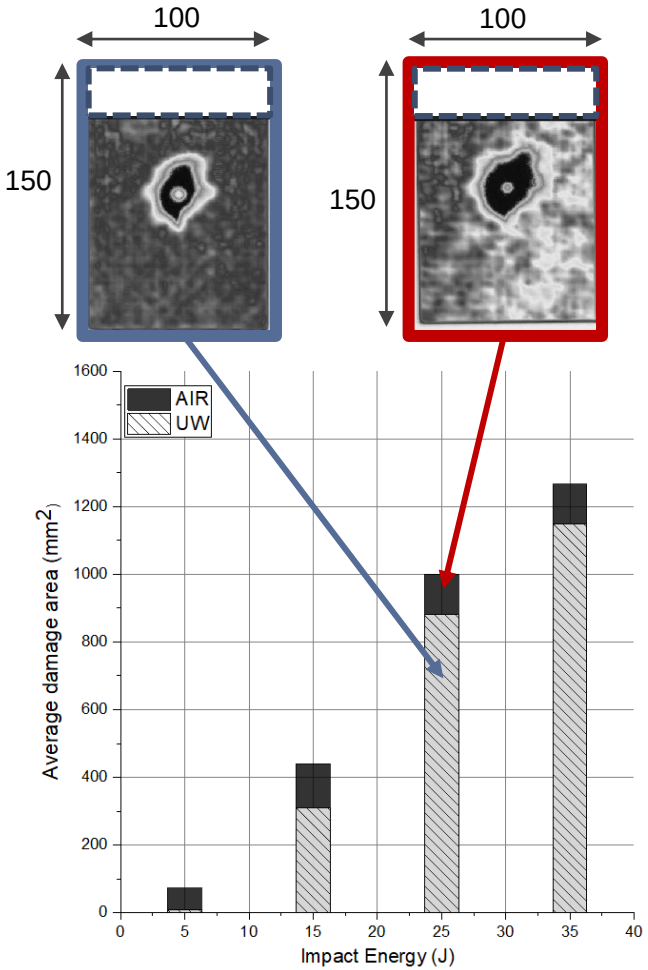
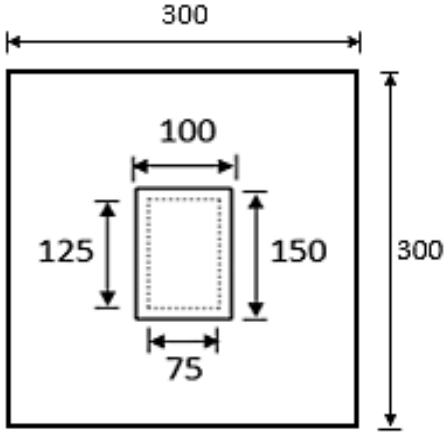


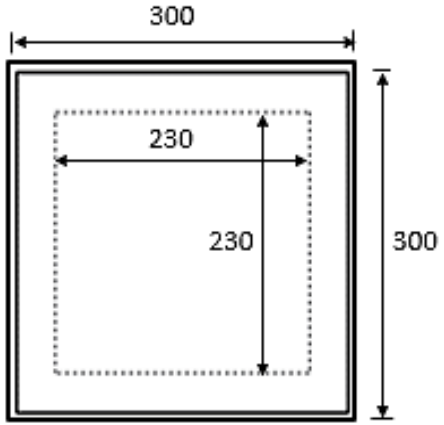


OLD COUPON



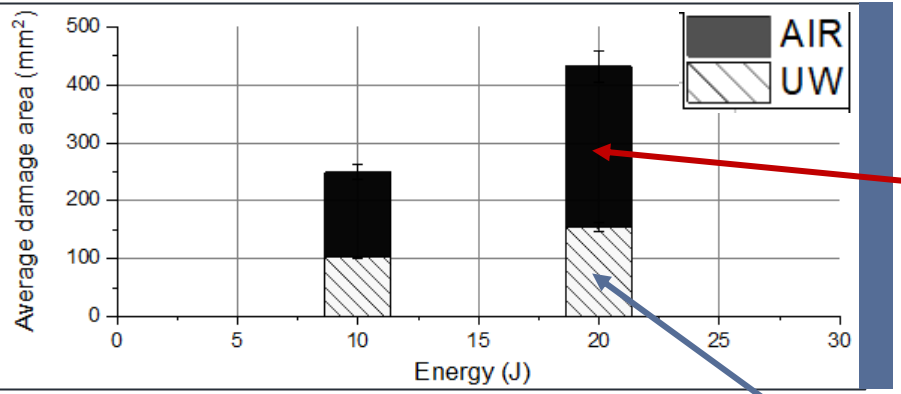
D7136 COUPON

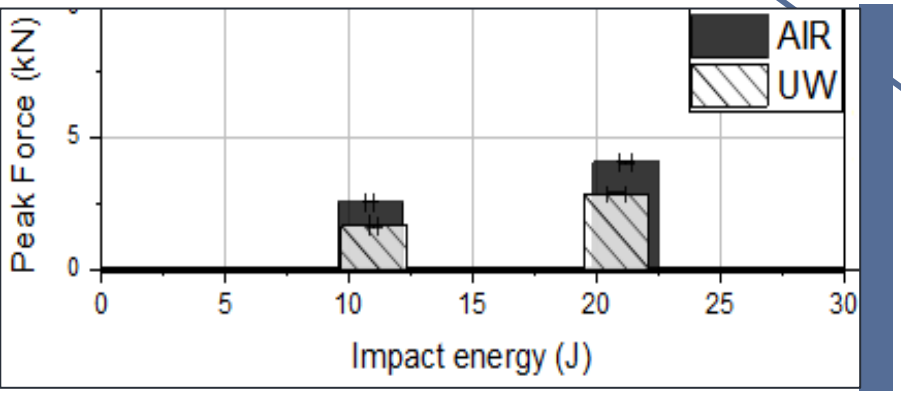
NEW COUPON

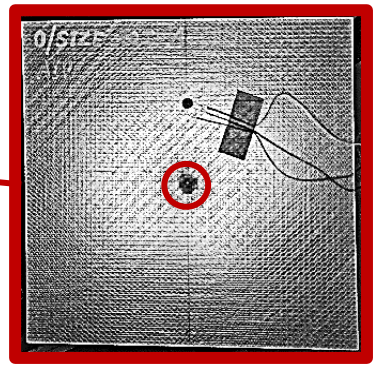


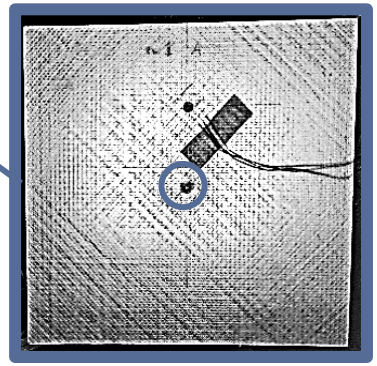
NEW COUPON

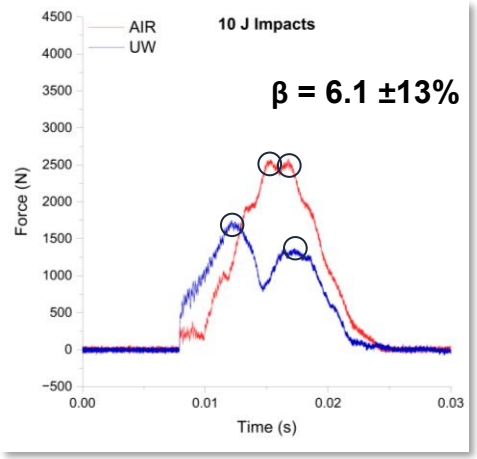
NEW COUPON

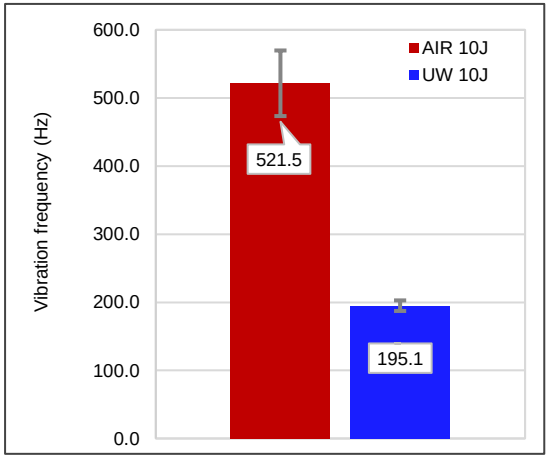

Average damage area (mm²)
500
400
300
200
100
0
0
5
10
15
20
25
30
Energy (J)
AIR
UW

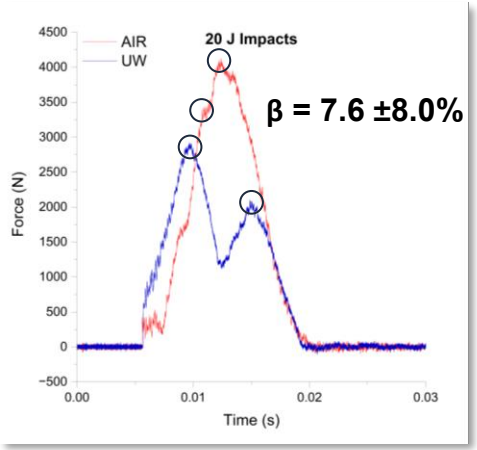

Peak Force (kN)
5
0
0
5
10
15
20
25
30
Impact energy (J)
AIR
UW

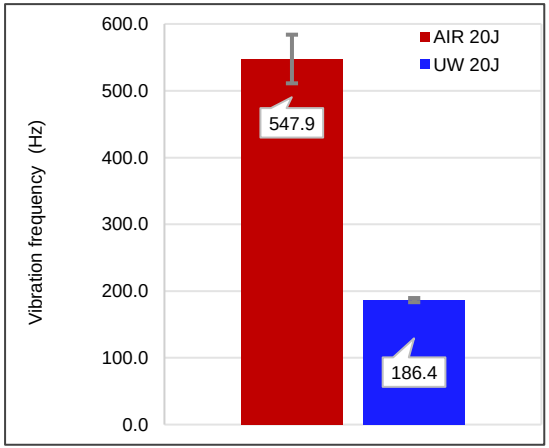












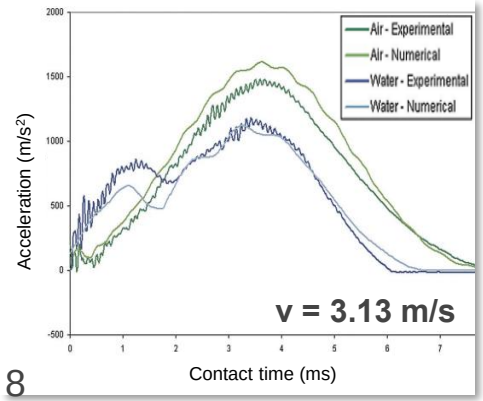
Added mass factor:

$$\frac{\omega_{uw}}{\omega_{air}} = \frac{1}{\sqrt{1+\beta}}$$

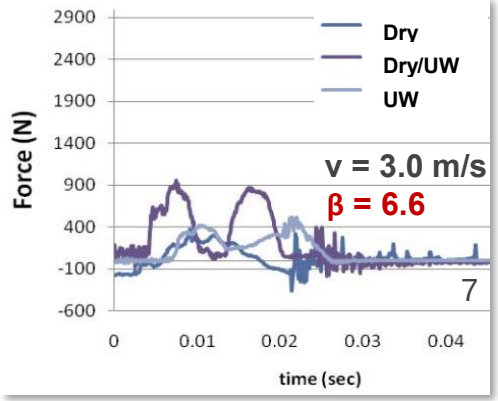
$$\beta = \left(\frac{\omega_{air}}{\omega_{uw}}\right)^2 - 1$$

NEW COUPON

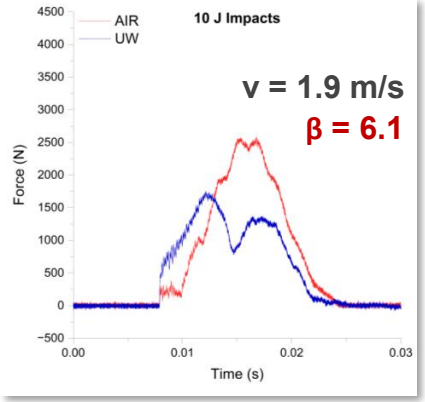
HAMPSON ET AL

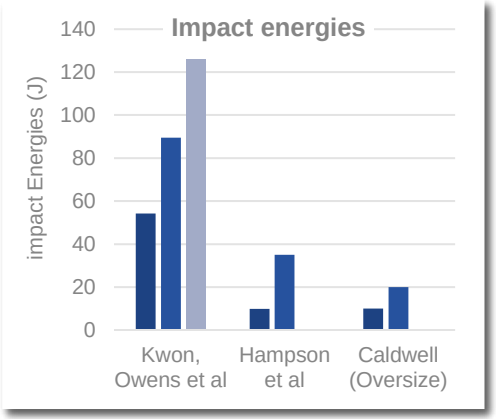


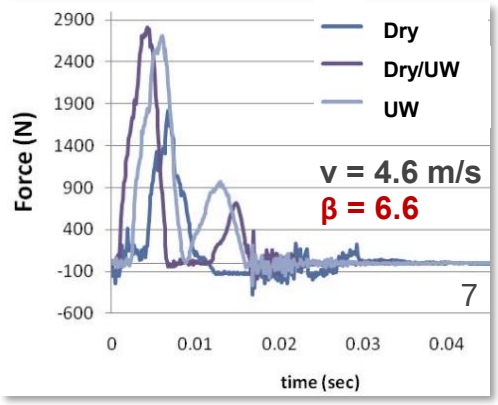
KWON, OWENS ET AL

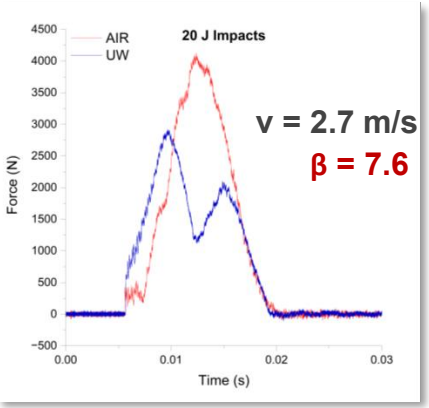


CALDWELL ET AL









DISCUSSION

CONCLUSIONS

1. EQUIPMENT

An existing, standardised and calibrated drop tower was retrofitted with a tank inside the impact chamber and successfully used for underwater impact testing in a traditional laboratory environment.

2. METHOD

The ASTM D7136 standard of composite impact testing is unsuitable for assessment of the impact performance of submerged laminates as submersion has an insignificant effect on impact response and impact tolerance.

3. COUPON

A larger, 300x300mm^2 coupon design was found to offer sufficient compliance to reliably measure the change in impact response and impact resistance of submerged laminates as opposed to laminates in air.

4. FSI EFFECT

The added mass factor was 6.1 +/- 0.8 for 10J impacts and 7.6 +/- 0.6 for 20J impacts.
Impact damage areas for submerged laminates were 60% smaller than for impacts in air due to approximately 30% reductions in submerged peak impact forces.

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THANKS

Does anyone have any questions?

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