Study on Cavitation Erosion of Composite Materials for Marine Propeller
T Yamatogi (Nakashima Propeller Co) H Murayama, K Uzawa, K Kageyama, N Watanabe (Univ of Tokyo)
We are developing the new propeller made of composites that have advantages for the energy conservation of ships. However, we found that fibre reinforced plastics are not resistant to erosion by cavitation to which the propeller is exposed. In this study we investigated the cavitation erosion of various kinds of composite materials. (A4:1)

The Advanced Technology Mast for HMS Ark Royal
C Kane (QinetiQ) A Bain (MOD)
The Royal Navy has adopted composites technology for use in its advanced technology mast. The mast has been designed, installed and is currently in-service on one of the UK's aircraft carriers, HMS Ark Royal. The multi-functionality of the materials has enabled the varied and complex design drivers to be met. (A4:2)

The Design and Build of the Spars on the Sailing Superyacht Maltese Falcon
J Brickwood, D Roberts (Schlumberger Subsea Surveillance)
High bending and torque loads, and complex internal structures created demanding design conditions for these three 58m high, freestanding, 15t high strength carbon masts on this award sweeping 290 ft vessel. Fibre-Optic real-time load sensing was key to optimizing design approach and load control for the as-built rig. (A4:3)

Design and Analysis of DLS Steel/Composite Thick-Adherend Adhesive Joints
S Hashim, C Berggreen, N Tsouvalis, D McGeorge, I Chirca, S Boyd, P Moore, E Juin, J Nisar, K Anyfantis, K Misirlis (Univ of Glasgow)
Thick-adherend double lap shear (DLS) joints are relevant for butt connections in modern ship fabrication or for patch repair of steel structures. In any case this requires guidance on design and analysis in relation to materials combination and joint geometry including overlap length. The results of a parametric study including both experimental and numerical modelling analysing a wide spectrum of joint geometries and materials are presented. (A4:4)

Formulation Based on Advanced ATM for Long-Term Fatigue Life Prediction of CFRP Laminates for Marine Use
Y Miyano, M Nakada, H Cai (Kanazawa Inst of Tech)
The main objectives of this paper include: (a) proposing theoretically an advanced accelerated testing methodology (advanced ATM) for the long-term fatigue life prediction of polymer composites on the viewpoint of viscoelastic behavior of matrix resin; (b) verifying experimentally the proposed advanced ATM for CFRP laminates for marine use. (A4:5)

Verification of Failure Process in Accelerated Testing Method
H Saito, I Kimpara (Kanazawa Institute of Technology)
In order to establish more reliable accelerated testing methodology (ATM) for FRP laminates, failure process through the accelerated tests is verified by the “in-situ” precise observation method, which can trace the damage propagation behaviour more directly and simply than the previous approach. (A4:6)
Engineered Interphase in Carbon Fiber-Vinyl Ester Composites
F Vautard, LT Drzal (Michigan State Univ)
The mechanical properties of carbon fiber-vinyl ester composites are low compared to carbon fiber-epoxy composites, mainly because of lower interfacial adhesion. The origins of that well known phenomenon were investigated. A partially cross-linked epoxy sizing was found to sharply improve the interfacial adhesion. (A4:7)

The Research Base for FailureCriteria.Com
R Christensen (Stanford Univ)
A new website on failure criteria for engineering materials is outlined. Included is a new failure form for aligned fiber composite materials. It is fundamentally different from the Tsai-Wu, the Hashin, and the Puck forms, and all other previous forms. The derivation and a realistic, physical application are given. (A4:8)

Damage Detection in Composites with Indentation Tests
R Batra, W Jiang (Virginia Polytechnic Institute & State Univ)
We use the Eshelby-Stroh formalism to study the indentation of a laminated composite to identify damage through changes in the slopes of the load vs. indentation curves. It is found that the slope varies noticeably with the location and the width of the delamination crack. (A4:9)

Strain Rate and Temperature Dependency on the Nonlinear Behavior of Woven Composites
L Xing, K Reifsnider (Univ of Connecticut)
A polymer-based woven composite was selected and has been characterized using off-axis composite specimens at different strain rates and temperature. A strain rate–temperature equivalence principle is introduced to describe the nonlinear behavior of selected composites. Experimental data shows the validation of the proposed method. An application of comparing the large-strain constitutive theory for describing the nonlinear behavior of woven composites under dynamic loading and the strain rate–temperature equivalence methodology for experiment implementation was presented. (A4:10)

Strength of GRP-Laminates with Multiple Fragment Damages
S Kazemahvazi, J Kiele, D Zenkert (KTH)
The strength of glass fibre reinforced vinyl-ester laminates with multiple holes has been investigated experimentally. Different hole pattern configurations have been tested, primarily for unidirectional laminates. Unidirectional laminates have shown very low notch sensitivity and the laminate failure was governed by two competing failure modes; shear off failure and net section tensile failure. (A4:11)

Failure of Liquid-Filled Filament-Wound Composite Tubes Subjected to Axial Impact
K Inaba, JE Shepherd (California Institute of Technology)
We have studied the damage and rupture failure of water-filled filament-wound composite tubes due to stress waves generated by fluid-structure interaction resulting from axially-directed projectile impact on the water. Onset of the failure appears to be transverse cracking for the 45± tubes and through-lamina cracking for the 60± tubes. (A4:12)

Effects of Panel Stiffness on Slamming Responses of Composite Hull Panels
M Battley, T Allen (Univ of Auckland) P Pehrson, I Stenius, A Rosen (KTH)
The effects of stiffness on slamming responses of composite marine hull panels are experimentally characterised and compared to theoretical predictions of hydroelasticity and transient structural responses. Results demonstrate that the panel stiffness has a significant effect on the responses, causing reductions in loads and strains in some regions of the panels, and increases in others. (A4:13)
A Plausible Method for Fatigue Life Prediction of Boats in a Data Scarce Environment
DMV Roberton, RA Shenoi, SW Boyd (Univ of Southampton) S Austen (RNLI)
Within the marine world many boats are constructed from composite materials, that use classification society rules to predict their strength. As these vessels age, fatigue and remaining lifetime are of considerable interest to owners and operators. This paper seeks to identify an appropriate S-N curve and produce an example lifetime calculation. (A4:14)

Repair Efficiency of Resin Infused Scarf Repair to Marine Sandwich Structures
JPalaniappan, SW Boyd, RA Shenoi (Univ of Southampton) J Mawella (MOD)
Modern vacuum-assisted resin infusion scarf repair technique is adopted for single skin and core damage of balsa core sandwich structure and different repair configuration studies are carried out to improve the repair effectiveness. Four-point flexure testing with repair both in tension and compression is done and the failure modes studied. (A4:15)

Design for Production in FRP Boats
AJ Sobey, JR Blake, RA Shenoi (Univ of Southampton)
Boatbuilding is an industry with tight profit margins and high global competition. To try and improve the competitive edge designs must be cheap, well built and luxurious. This paper therefore looks at structural optimisation methods including reliability of parts to produce low cost well designed boats using design for production. (A4:16)

Specific Mechanical Properties of Glass/Carbon Epoxy Composites for Marine Applications
A Valenza, V Fiore, G Di Bella (Univ of Palermo)
The aim of this work is to study the influence of an uniaxial carbon fabric layer on the mechanical performances of a glass mat/epoxy composite used for marine applications. All structures are realized, at room temperature, with vacuum bagging technique. Flexural tests are carried out in order to evaluate the specific properties of the composite. (IA4:1)

Effect of Hollow Inclusion-Matrix Debonding on Elastic Properties of the Composite
M Porfiri, G Tagliavia, (Polytech Inst of New York Univ)
This work aims at understanding the effect of particle-matrix interfacial debonding on the elastic properties of hollow-particulate filled composites. An analytical solution is derived for a hollow-inclusion embedded in an infinite matrix for various debonding levels. The results show stress intensification at particle-matrix interface along with a remarkable dependence of the composite stiffness on the debonding extent. (IA4:2)

Experimental and Numerical Study of Meso Scale Adhesive Bondable Pultrusions
J Nisar, S Hashim (Univ of Glasgow)
This study seeks to develop a methodology to mould and test a 10x10mm "meso-scale" laminates of various materials combinations which represent critical locations within pultruded adhesive bonded butt joints. This, together with numerical modelling, enables a better understanding of joint strength which may not be achieved on a macro-scale level alone. (IA4:3)

Compression after Impact of E-Glass/ Vinyl Ester Laminates with Machined Holes Versus Ballistic Impact Penetration Apertures
S Pillay, E Anderson, U Vaidya (Univ of Alabama) B Rice (Rhodes College) K Jaamiyana (Colorado State Univ)
E-glass/vinyl ester (E-glass/VE) composite laminates are routinely featured in marine applications such as a ship structure deck, hull and radar mast. These composites witness attacks from bullet fire, fragmentation and blast events, leading to significant reduction in their residual mechanical properties. Ballistic penetration damage has several similarities to a machined hole, with the exception that through the thickness micro debonds are distinctly defined in ballistic damage. (IA4:4)

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