Fluid Structure Interactions Research Group

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Damaged Composite Marine Structures

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Background

Glass reinforced plastic, GRP, is used in over 100 mine counter-measure vessels around the globe for its low signature characteristics. The UK MoD mine counter measure vessels (MCMVs) are constructed from single skin E-glass polyester hulls stiffened with longitudinal and transverse "top-hat" stiffened frames and girders with bulkheads secured to the deck and hull using "tee-joint" connections. Composite joints are critical in assessing the structural performance in the vessel. MCMVs commonly incur damage through impact. and delamination and debonding damage are some of the most commonly observed faults

One of the major recent incidents faced by the UK MoD was the grounding of HMS Grimsby off the coast of Norway in March 2006. She suffered areas of damage including known structural failure, suspected structural failure, water ingress and external hull damage. Both hand assessment and finite element analysis were carried out by QinetiQ in order to determine her residual structural capability and determine the damage response process. However, during this process a number of research tasks were highlighted to increase the readiness of the UK MoD composite naval vessels and the lack of readiness for a damage incident from a structural perspective.

This incident highlighted that there is limited information is available on the residual strength of a damaged vessels which is critical in deciding the appropriate course of action following damage. There is an a lack of extensive knowledge on how to assess and characterize damage, it's progression and how to survey, repair and design against it. Composite joints are critical in assessing the structural performance in the vessel and delamination and debonding damage are some of the most commonly observed faults.

Problem Statement

There is a need to assess macroscopically the effect of varying degrees of damage and the relationship between the type, extent and quantity of the damage within naval composite ships and the residual strength of the structure under realistic operational loads.

Research Purpose

The expected output is to generate guidance for damaged vessels and analytical tools to assess performance capability of damaged joints and panels and ultimately the primary ship structure. These tools, for predicting mechanical response of damaged composite structures, may be utilised with an analysis system incorporating wave data and results of hydrodynamic wave load prediction tools to evaluate probable loading during operational scenarios and the response of the vessel.

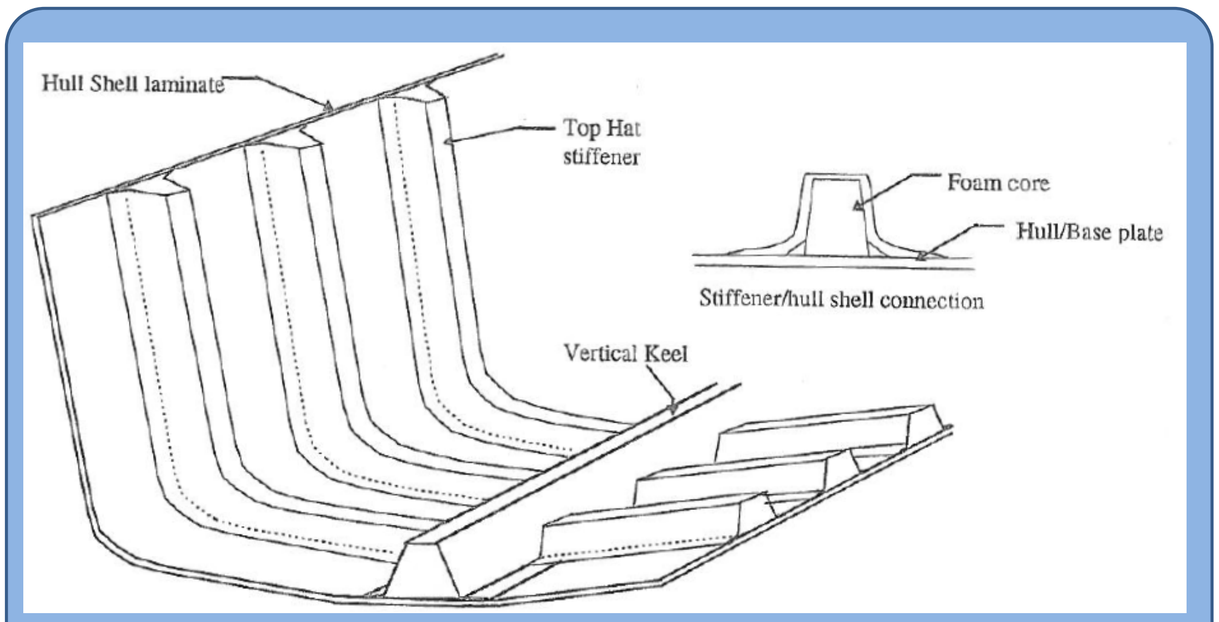
Context

This research is to be conducted with reference to the UK MoD MCMV fleet, in stiffener configuration, lay-up and associated properties and will therefore build on associated research conducted by the UK MoD.

Initial research will build on previous MoD research into the fracture and growth of delamination damage within a composite stiffened panel.

A review of damage type and severity in damage incidents on UK composite ships will guide the research in terms of type, severity and probability of damage incurred following different damage incidents.

Development of a preliminary 3D FEA model replicating previous experimental work to verify progressive damage technique and incorporating fracture mechanics data.



^ *Figure 1: 'Typical Monolithique Hull Configuration*

< *Figure 2: HMS Grimsby*

Future Work

Development of a model determining the mechanical response and effect on the capabilities of representative panels for a composite MCMV, given varying extents of delamination, de-bond and associated damage, and to assess the critical extent of damage to a panel before repair is required.

The following sub objectives are outlined:

1. Review of damage type and severity following incidents to naval mine hunters
2. Develop a numerical model capable of predicting the response of composite stiffened panels under quasi-static loads and combined loading.
3. Verify numerical model against literature or experimental data
4. Incorporation of delamination zone into the numerical model to predict the response of composite stiffened panels under quasi-static loads
5. Conduct sensitivity analysis to determine size and extent of damage within a composite stiffened panel
6. Conduct sensitivity analysis to determine size and extent of damage within extended hull configuration

Conclusion

UK MoD composite MCMVs commonly incur damage through impact causing delamination, de-bonds and other associated damage. However, as highlighted by the HMS Grimsby grounding situation, limited information is available on the residual strength of a damaged vessels which is critical in deciding the appropriate course of action following damage.
This research will generate guidance for damaged vessels and analytical tools to assess performance capability of damaged joints, panels and ultimately the primary ship structure. By use of progressive damage and fracture mechanics approaches, the ultimate strength of the panel will be determined for varying damage parameters and therefore assessing the reliability of the structure.

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