EFFECTS OF COMPOSITE OVERLAMINATION PATCHES TO IMPROVE FATIGUE LIFE OF WELDS

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Introduction

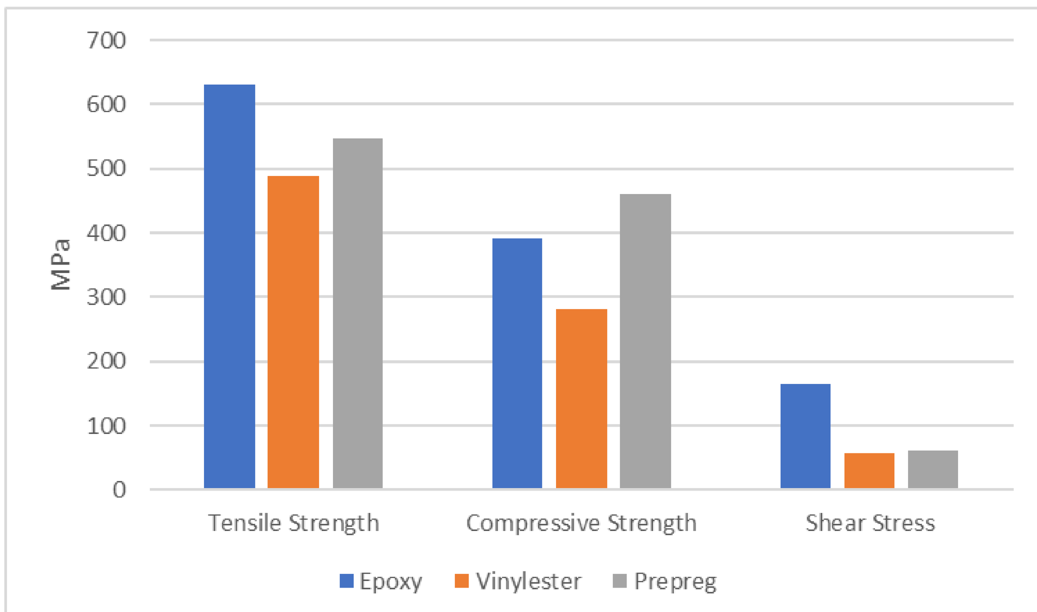
- Today's merchant and passenger vessels, such as Tankers, Bulk Carriers, Container Ships, Cruise Vessels and Ferries are complex structures that operate in harsh environments with respect to static and cyclic loads and corrosion.
- Usually, ships are designed to reach useful lives around 25-35 years with the need to perform maintenance operations, repairs and/or appropriate replacements to ensure, in short, the operation and safety of the same during that period.
- Ships are built using conventional marine steels in order to meet the structural requirements for accommodating loads exerted by the marine environment and from normal ship operations.
- Depleting funds for fleet renewal and increasing through-life cost of maintenance and repair are the principal factors that lead to the need to implement new solutions that are easy to apply and low cost.
- All this added to the growing need for lightening in the transport sector turn the FRP materials into the main candidates as drivers for this change. The research and development in this study is addressed to the development and study of solutions based on fibre reinforced plastics (FRP) overlay to improve life in service of metallic shipbuilding structures.

Materials

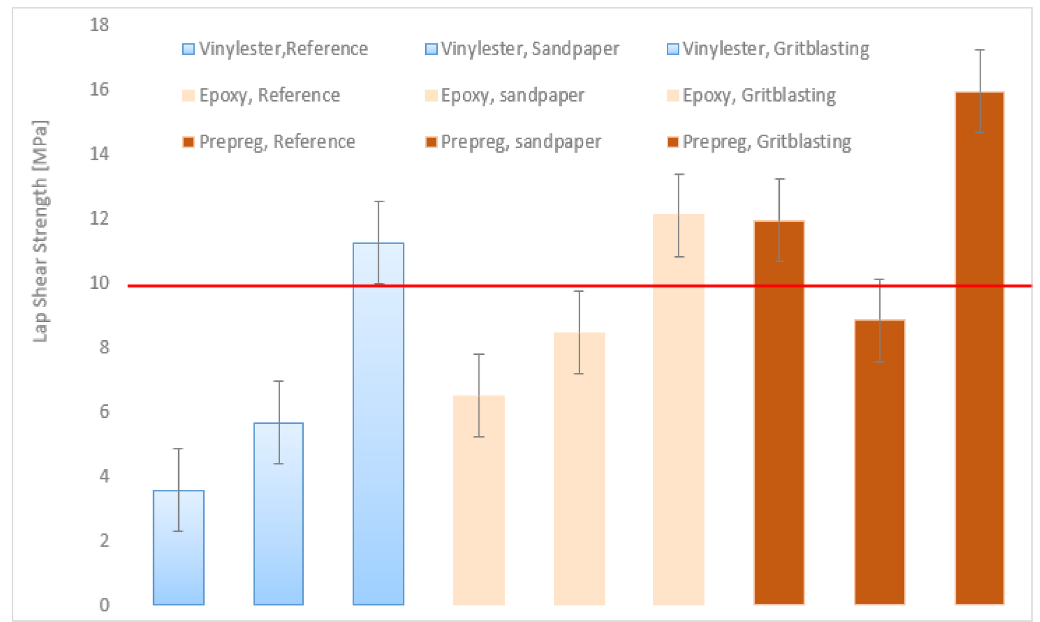
- **HSLA steel:** S460-S460
- **Welding process:** Fluxed Cored Arc Welding (FCAW)
- **Welding post treatment:** Composite Overlamination
- Adhesive type: Resin Liquid
- **Patch composite:**
  - Carbon Fibre Bidirectional Fabric: CC 200 P – 120 (KordCarbon)
  - Vinylester resin: Epovia® Optimum KRF 4436 AI (Polynt Composites)
  - Epoxy resin: PRIME^{TM} 27 EPOXY INFUSION SYSTEM (Gurit)
  - Prepreg Carbon Fibre Epoxy resin: VTTM 246-42%-3KHS-2X2T-1999-1250 (SOLVAY)

Experimental Procedure

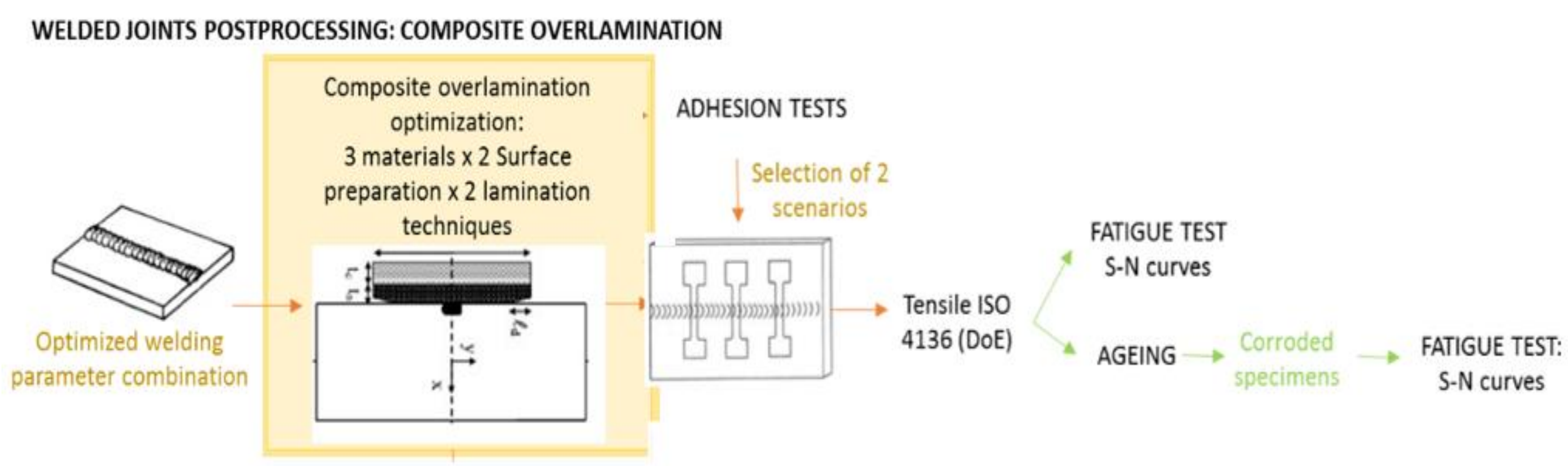
Characterization of CFRPs laminates



Characterization of the Hybrid Joints, ASTM 5868



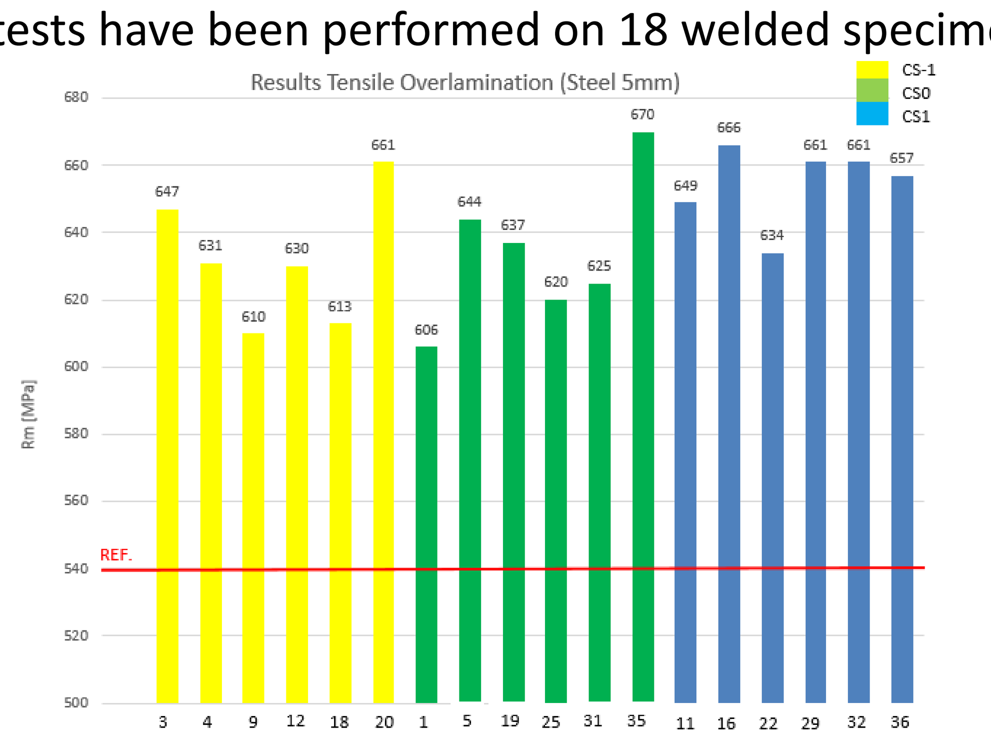
- **Strategies followed to study the composite overlamination of welded joints:**



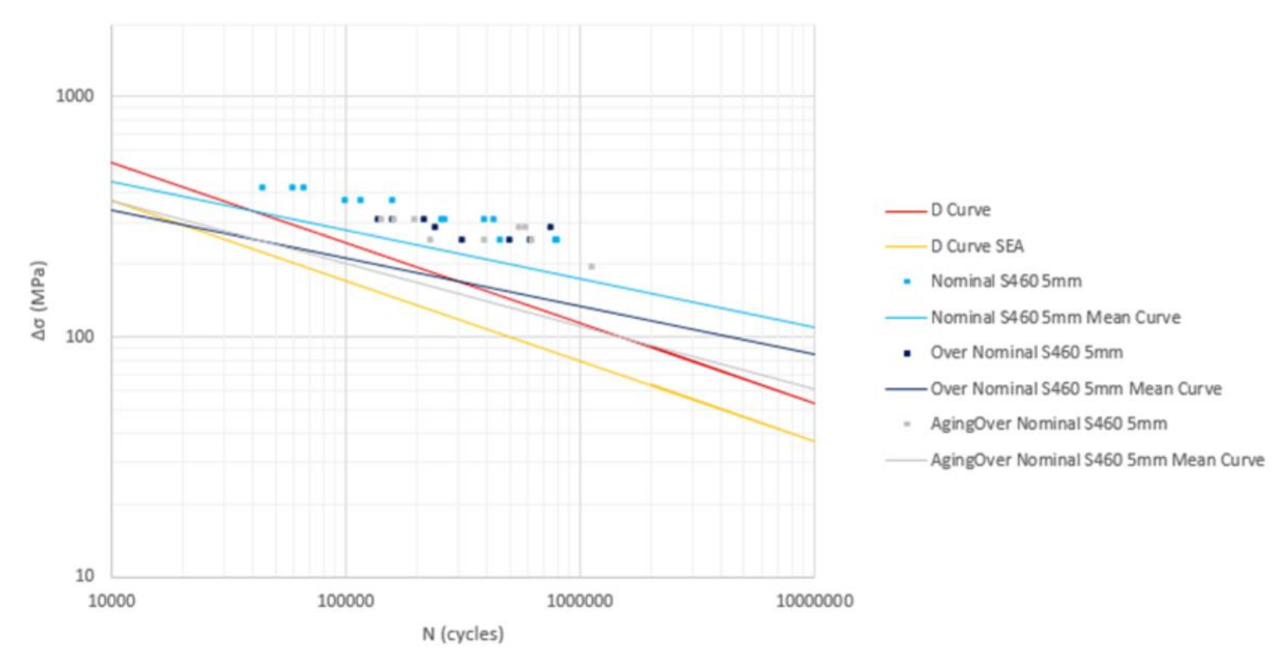
This present study developed the patch configuration and design: the optimum configuration of the composite has been analyzed and calculated.

Results and Discussion

- A DoE has been performed in order to obtain overlamination procedure definition and parameter optimization. The numeric factor studies were: 3 values of stiffness ratio, SR, 3 values of patch width over weld width ratio, composite systems: carbon/epoxy, carbon/ vinylester, carbon prepreg; process of manufacturing: HLU and HLU+vacuum. The parameters were fixed: welded solutions of HSLA by FCAW, without adhesive bonding, and surface preparation, grit blasting (left).
- The second phase for composite overlamination is determine S-N curves of a combination of HSLA steel and composite overlamination effect on fatigue behaviour. Fatigue tests have been performed on 18 welded specimens and 9 of them have been subjected to ageing conditions (right).



Tensile Test Results UNE-EN ISO 6892-1 for Composite Overlamination DoE (steel thick 5mm).



Free slope 97.7% survival curves with nominal values of fatigue tests on S460-S460 combination with Overlamination and with Overlamination aged.

Conclusions

- Overlamination has a FAT of 116.27 which is better than D curve in air (according to Ni611), which is 91.25.
- Aging exposure has caused a worst fatigue behaviour (FAT92.09) than without aging (FAT116.27). Instead of that, it had a better FAT than D curve in seawater without corrosion protection (according to Ni611) which is 63.27.
- After the fatigue test, the most important result is that both combinations, composite overlamination without corrosion and with corrosion on welded steel S460-S460, have an acceptable fatigue behaviour.
- This study helps to change the vision of the way to repair different structures, metallic and non-metallic, using composite capabilities as well as to think lightweight. Composite overlamination as a patch improve on arresting the crack progression for steel and also would be used to increase lifespan of welded joints even under corrosion exposures.

Acknowledgments

The authors want to acknowledge the received funding from the European Union's Horizon 2020 Research and Innovation program under grant agreement nº 723246 (https://www.ramsses-project.eu/).