Structural integrity assessment of functionally graded components created using additive manufacturing technology for marine applications

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Introduction

The new emerged technology of additive manufacturing (AM) has the potential to significantly improve a lifespan of the structure by managing the residual stress fields and microstructure in the future generation of offshore structures, and moreover reduce the manufacturing cost.

Aims and objectives

Explore the possibility of creating a managed residual stress field and microstructure in future offshore structures using multi-metallic-layer Wire+Arc Additive Manufacture (WAAM) technology.

Results and discussion

A number of studies have shown that AM parts compared with wrought specimens have:

- Similar yield and ultimate tensile strength (mild steel)
- Higher Charpy impact tests results (steel)
- Comparable or higher fracture toughness (titanium)
- Greater median number of cycles to failure (stainless steel)
- Lower fatigue crack growth rates (stainless steel, titanium)
- Similar corrosion-fatigue rate in hot water (stainless steel)

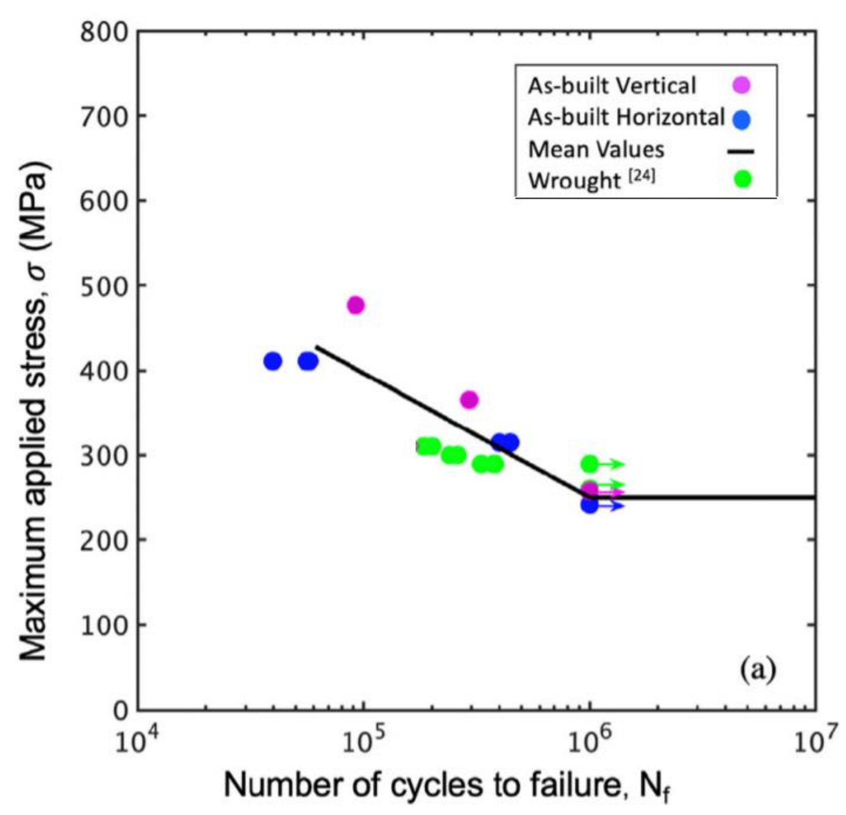

Figure 1 S-N curve for printed WAAM and wrought 304L steel

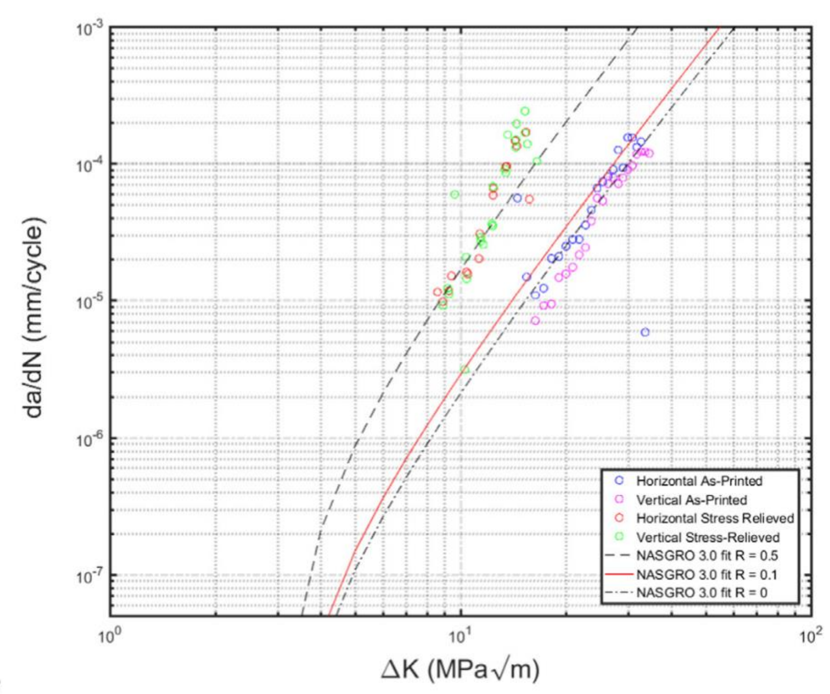

Figure 2 Comparison of fatigue crack growth rate of WAAM SS specimens to wrought material

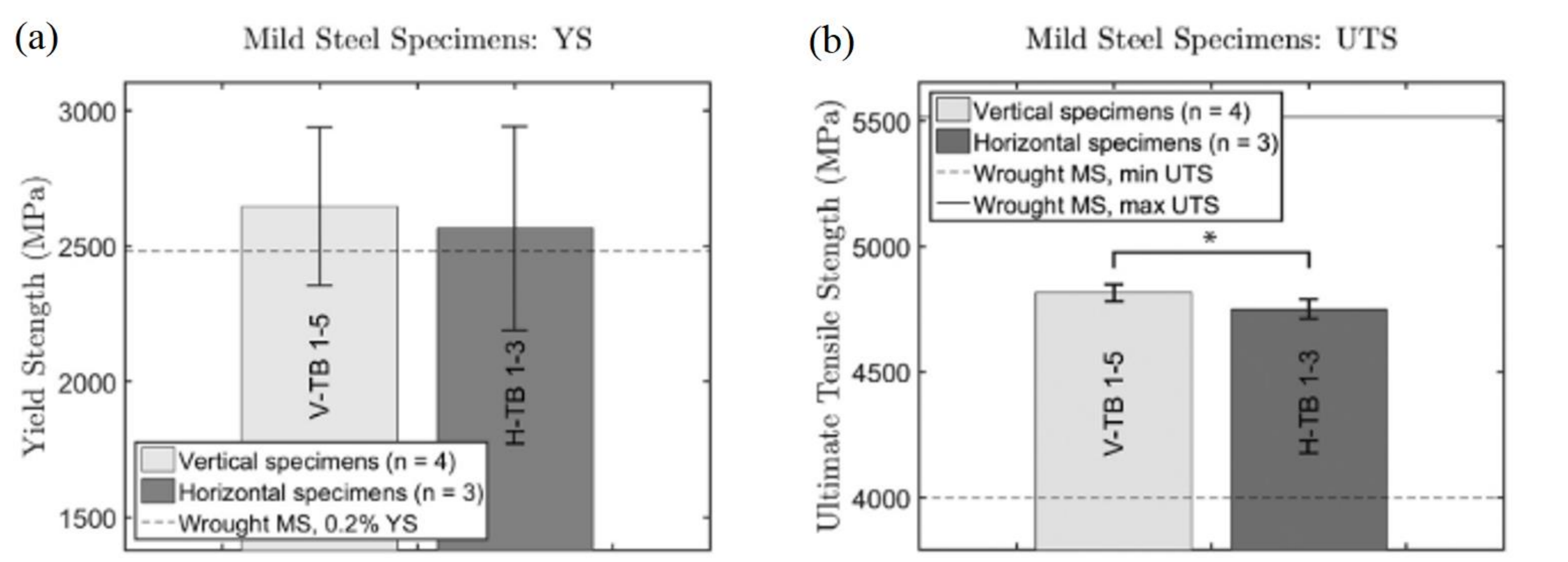

Figure 3 ER70S-6 material characteristics (a) yield strength (b) ultimate tensile strength

Conclusions

- AM shows tremendous potential for application in offshore wind industry
- Very limited data on AM techniques and new materials are available
- Better metallurgical knowledge of AM parts needs to be developed by systematic experimental and numerical studies

Future work

- Investigate the fatigue crack growth behavior of WAAM components in air and sea water
- Consider different grades of mild steel
- Characterise residual stresses and surface treatment effects on the fatigue performance

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