Fatigue analysis of a structural steel for ocean systems applications considering seawater environment

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Background and Motivation

Fig. 1. Offshore structures

In 2023, global energy crises and dependency on fossil fuels became more evident due to the Russia-Ukraine conflict [1]. Moreover, heat waves are becoming more frequent events, as a consequence of global warming [2].
Therefore, green energy sources, such as wind, can play an important role to mitigate these problems. In 2022, a total of 78 GW of wind power capacity was installed worldwide and 11% of it was offshore. However, in 2026, it is expected a new installation of 157 GW, and 26% will be offshore, as result of a great investment in this market.
Consequently, the assessment of structural integrity and life cycle of offshore structures is an emergent topic [1].

Main Goals

- ✓ Characterize corrosion mechanism in S690 QL steel;
- ✓ Analyse fatigue behaviour of S690 QL steel considering seawater environment;
- ✓ Determine fatigue strength reduction due to a corrosive environment

Fatigue behaviour and seawater environment

In this work, a fatigue analysis of S690 QL structural steel, with application in offshore structures, was performed. In order to evaluate the effect of a seawater environment in fatigue behaviour, specimens with and without induced corrosion were tested under cyclic axial loading with R=-1. A Tafel curve of S690 QL was experimentally determined and the conditions to induce accelerated corrosion were defined with the help of Faraday's law, considering a mass loss equivalent to 6 months in seawater environment.

Material characterization

Table 1. S690 QL steel mechanical properties

ρ $[kg/m^2]$	E [GPa]	σ_y [MPa]	σ_u [MPa]
7815	212	781	819

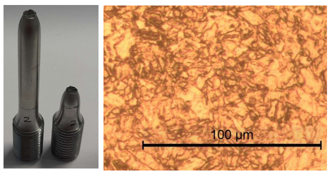

Fig. 2. S690 QL steel (a) tensile specimens (b) microstructure

Fatigue behaviour characterization

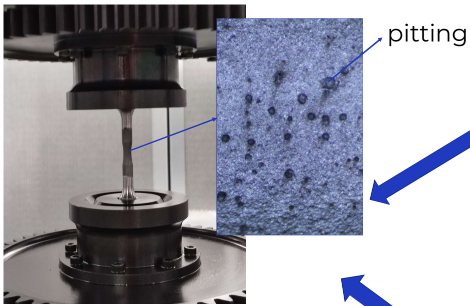

Fig. 3. Fatigue tests setup with surface detail

Corrosion behaviour analysis

Faraday's law [3]:

$$\Delta m = \frac{(AW)It}{nF}$$

Mass loss (Δm); Surface area (A); Atomic mass (W); Current (I); Time (t); Valency (n); Faraday's constant (F)

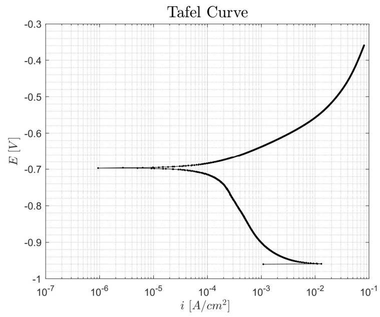

Fig. 4. Tafel curve of S690 QL steel

Accelerated corrosion

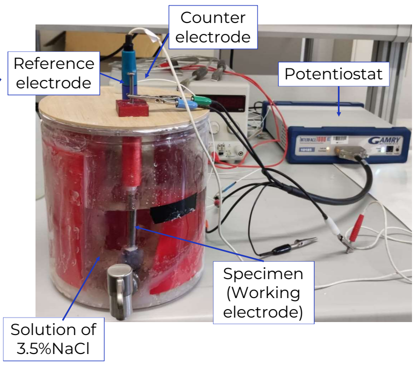

Fig. 6. Three electrode setup to induce 6 months in seawater environment

Conclusions

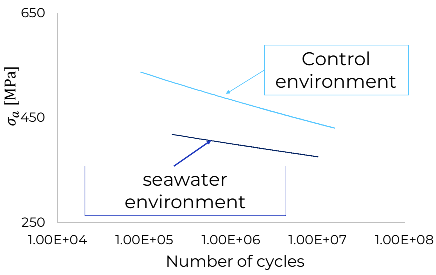

Fig. 5. Mean S-N curves of S690 with and without seawater influence

- ✓ A methodology to characterize corrosion behaviour of S690 QL steel as well as to induce accelerated corrosion was developed;
- ✓ Fatigue behaviour of S690 QL steel after accelerated corrosion equivalent to 6 months in seawater environment was assessed and summarized into a S-N curve;
- ✓ A considerable reduction in fatigue strength due to material degradation, induced by seawater environment, was observed;

References

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