REMS
RENEWABLE ENERGY MARINE STRUCTURES

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# Material Pre-Straining Effects on Fatigue and Fracture Behaviour of Offshore Wind Monopile Structures


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## Introduction

An important issue to be considered in the structural integrity assessment of offshore wind monopile structures is the influence of material straining introduced into structures during the fabrication process. A finite element model of the three roll bending process was developed to predict the influence of various fabrication factors on the resulting plastic strain.

## Aims and Objectives

The aim of this project is to investigate the impact of fabrication processes on the life assessment of offshore wind monopile structures.

- To determine the influence of material pre-straining on the fracture toughness, mechanical properties, and S-N fatigue (in air)
- To develop and validate finite element models to predict plastic pre-strain ad fracture toughness behaviour for monopiles
- To employ the obtained understanding of material pre-straining effects in engineering critical assessments of renewable energy marine structures

## Results

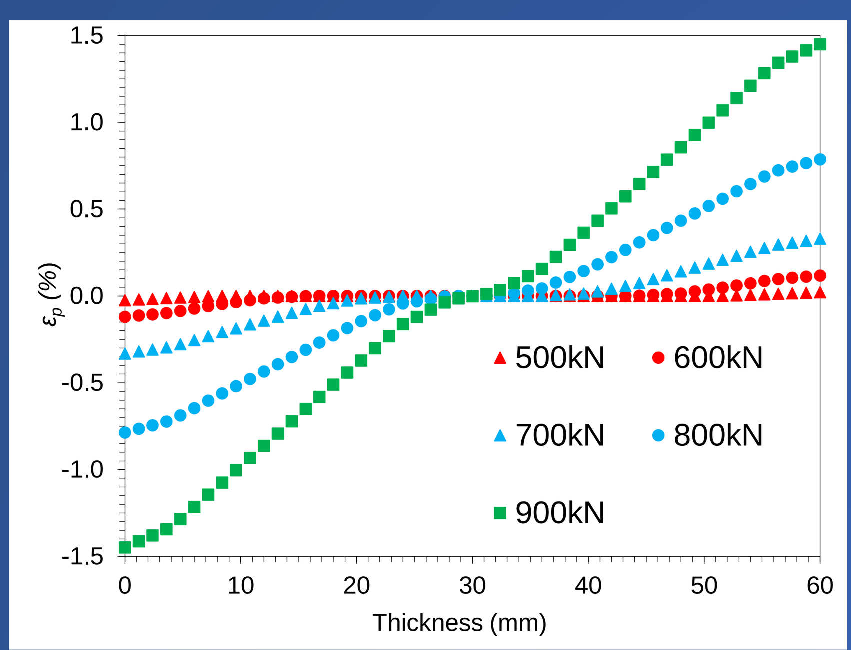

Figure 1

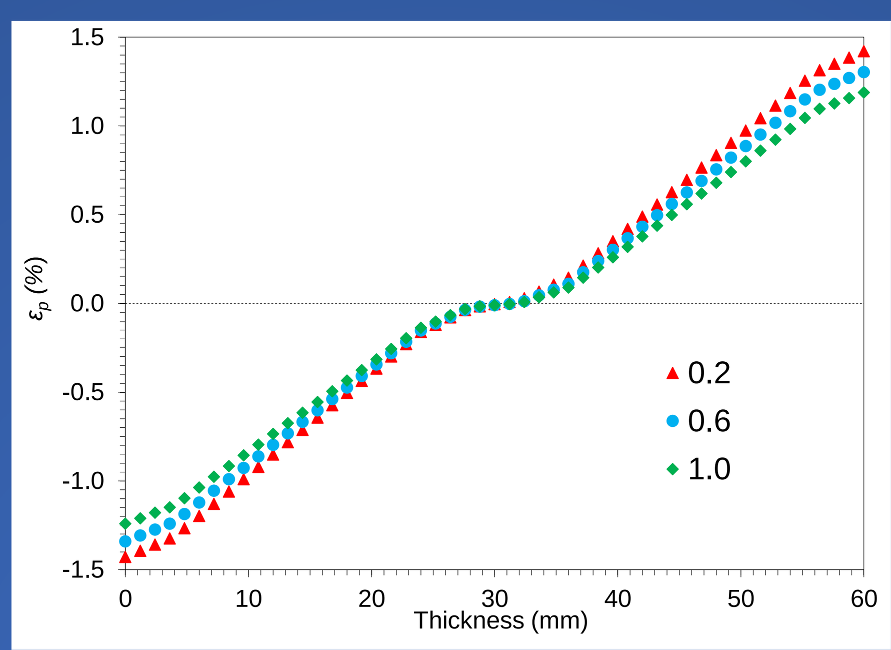

Figure 2

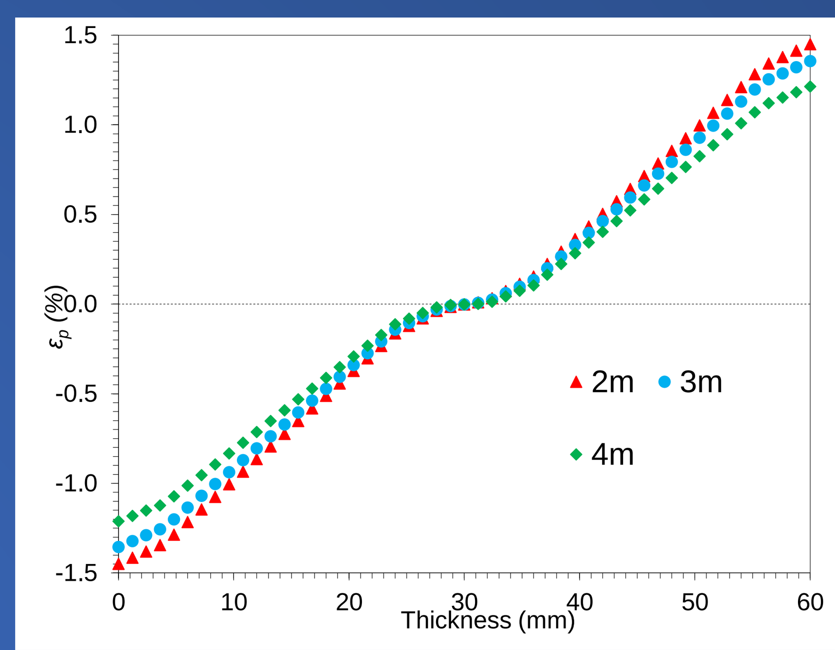

Figure 3

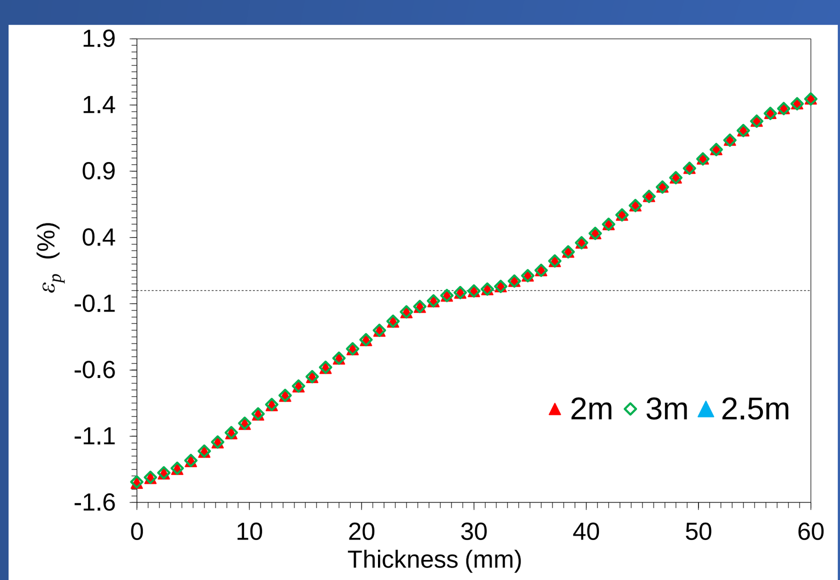

Figure 4

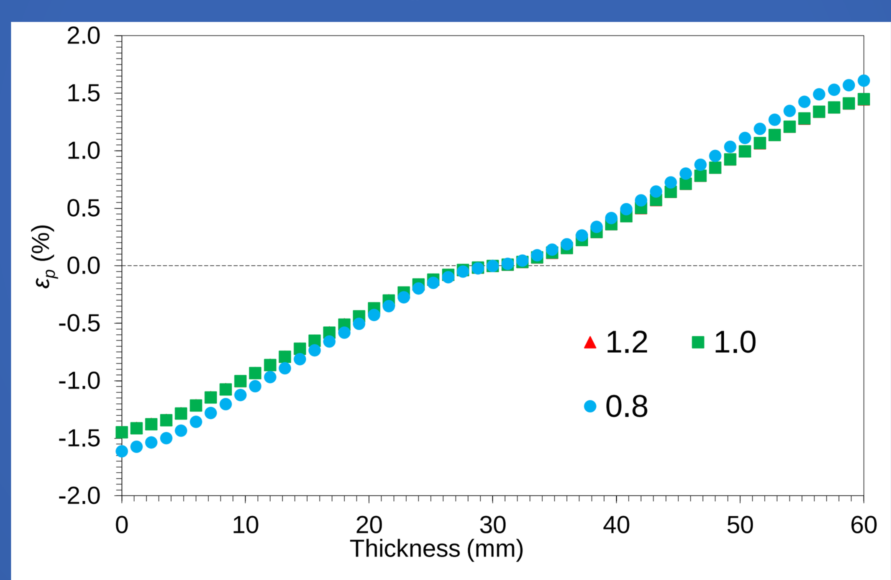

Figure 5

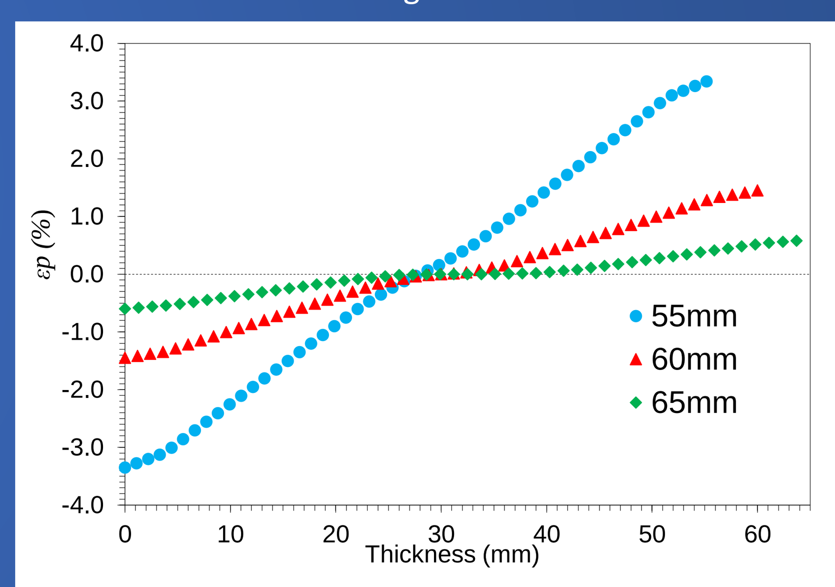

Figure 6

FEA simulations were run to simulate the effects of friction coefficient, loading conditions, plate thickness, distance between rollers, plate length, and roller diameter (figures 1-6 respectively). Plastic strain was observable from a loading condition of 500kN onwards. For metal forming processes, the friction coefficient is usually around 0.2-0.3. Changing the friction coefficient had some impact on the plastic strain levels, and this can be employed by fabricators to adjust the resulting plastic strain i.e. applying lubricants. Altering the distance between the rollers did not affect the plastic pre-strain levels. Decreasing the roller diameter by 0.2m resulted in a plastic strain increase, however increasing the diameter by 0.2m did not have significant effects on results. Reducing the wall thickness by 5mm can increase the plastic strain by 230%, and increasing the wall thickness by 5mm can decrease the plastic strain by 250%.


1. Plates of S355 are hot rolled


2. S355 hot rolled plates undergo cold rolling to form cans


3. Cans are longitudinally welded


4. Cans are circumferentially welded


5. NDT inspection techniques are undertaken


6. Monopile is ready to go offshore

## Conclusions

- Plastic strain observable from 500kN, with a 900kN maximum load examined and a maximum plastic strain of 1.45%
- Friction coefficient increases of 0.4 can result in a 0,12% reduction between cases
- Decreasing roller diameter by 0.2m results in a 10% plastic strain increase
- Wall thickness changes had the most significant impact on resulting plastic strain

## Future Work

- New tensile curves will be generated for various pre-straining levels to investigate changes in material properties
- Generation of new S-N curves for varying pre-strain levels
- Fracture toughness tests for future defect assessments on monopiles

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