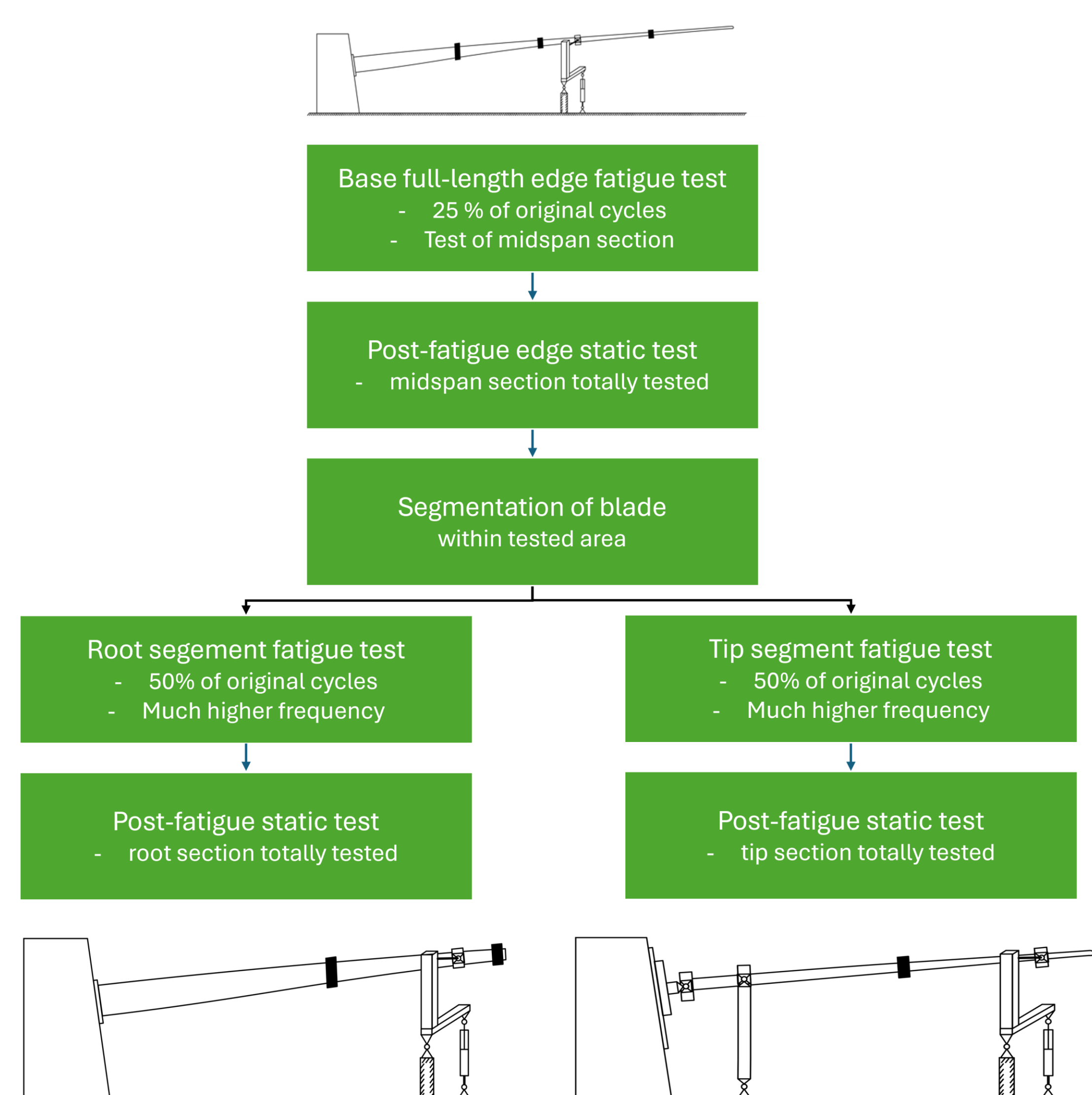


The potential of sequential testing of rotor blades

Accelerating fatigue testing of large wind turbine blades

Testing rotor blades for next-generation wind turbines presents significant challenges due to the increasing demands of modern designs, which feature higher rated power and very long, slender blades operating near material strength limits. Fatigue testing is conducted by exciting the rotor blade close to its eigenfrequency, which decreases further as blade length increases. Additionally, conventional full-scale testing methods often cause high overloads that lead to premature damage and time-consuming repairs. To mitigate these overloads, a higher number of test cycles at reduced load amplitudes and strains is typically employed. Consequently, the combination of extensive cycle counts, persistent overloads, and low blade eigenfrequencies results in prolonged fatigue testing and lengthy certification processes. Overcoming these challenges is essential to ensure the reliability and efficiency of future wind turbine blades.

Sequence of edge fatigue testing



Sequential Testing Approach

In a conventional fatigue test, the entire area of interest (AOI) is loaded simultaneously. To load the blade root properly, normally midspan sections will be overloaded, meaning that these sections reach their target damage after only a portion of the total cycles and are most likely to fail first. This makes adequate testing of the blade root challenging.

The idea of sequential testing is to distribute the damage accumulation over three separate tests to use the benefits of segmented testing without reducing the AOI. Initially, base-level damage is introduced through a standard full-length blade test, primarily loading the midspan section. Following this phase and a static test of the midspan section, the blade is divided into segments. The root and tip sections can then be loaded more precisely and tested at higher frequencies.

For both testing phases, damage is accumulated to achieve the target damage for the entire AOI. By reducing overloads and optimizing the test setup, the overall number of cycles required can be decreased. Higher frequencies in the segmented tests further reduce the total testing time.

Reduction of test time and overloads

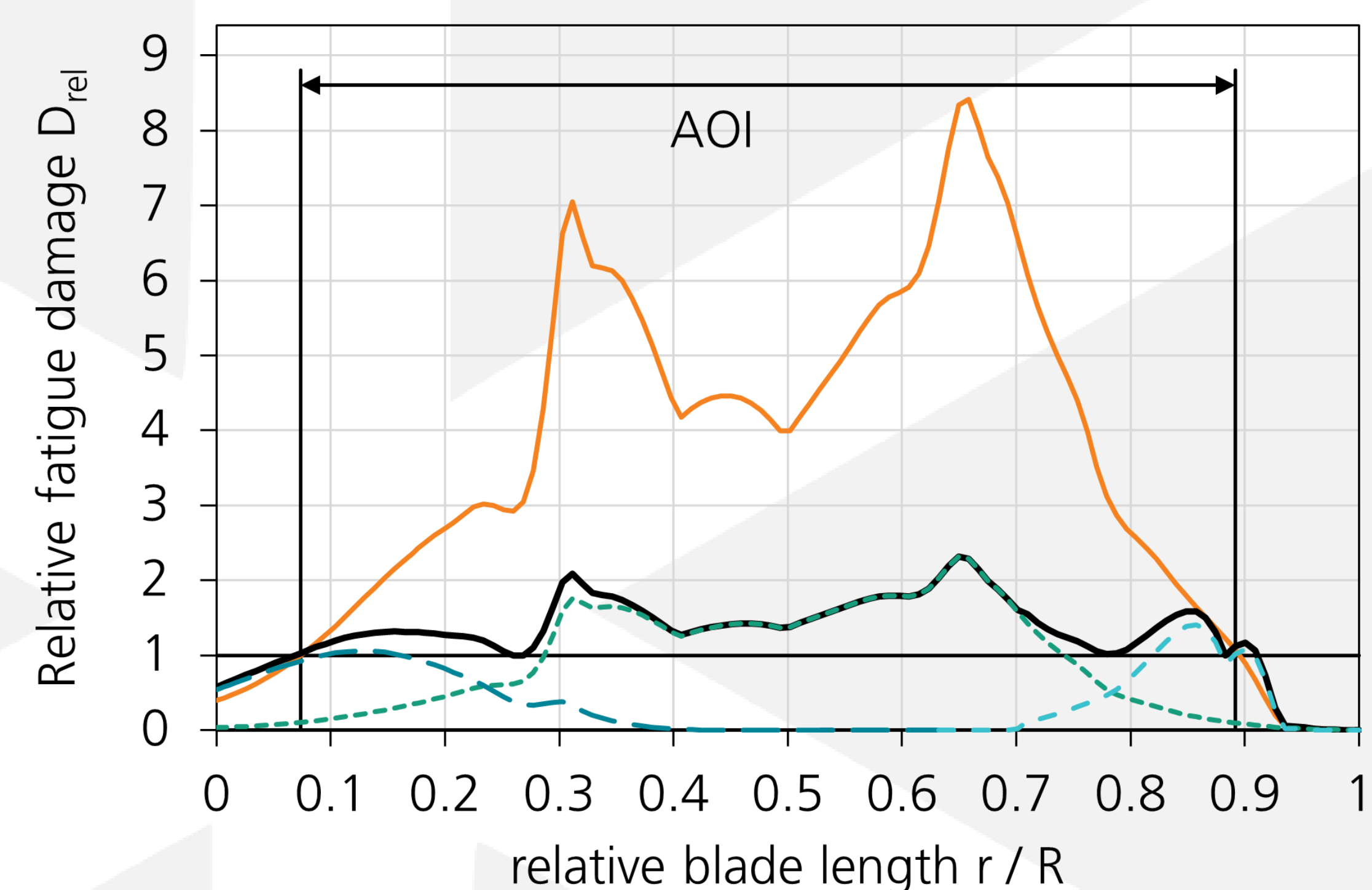
A case study was performed for an edge fatigue test of a more than 110m long rotor blade. The prediction indicates a remarkable time reduction of about 65% in the testing process, along with a significant decrease in local maximum fatigue damage by about 70%. These improvements highlight the effectiveness of the proposed sequential testing approach in enhancing the efficiency and reliability of rotor blade certification for next-generation wind turbines.

Picture credits:

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Comparison of introduced relative fatigue damage

- conventional test
- sequential, accumulated
- sequential, full-length
- sequential, root segment
- sequential, tip segment



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€35/MWh LCoE Goal, +12MW WEC Capacity, ~32 mio € Total Budget, 42 month project duration



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