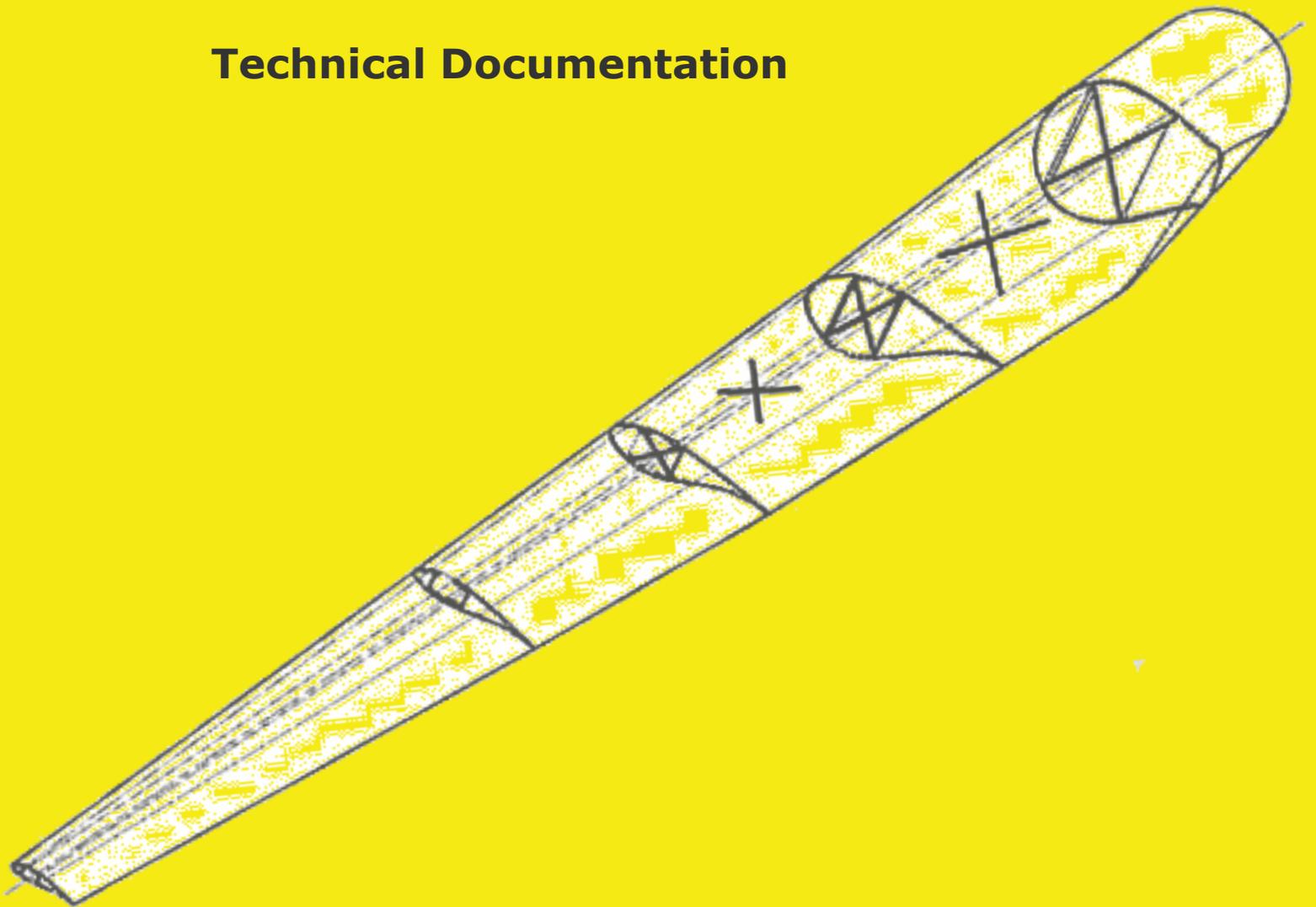


Bladena

BLADE ENABLER

X-StiffenerTM

Technical Documentation

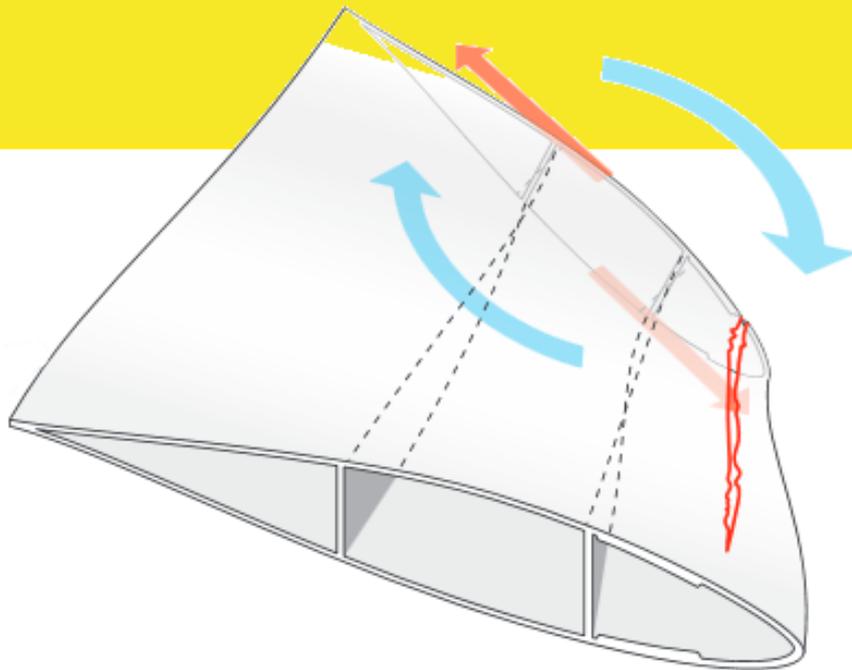


X-Stiffener™

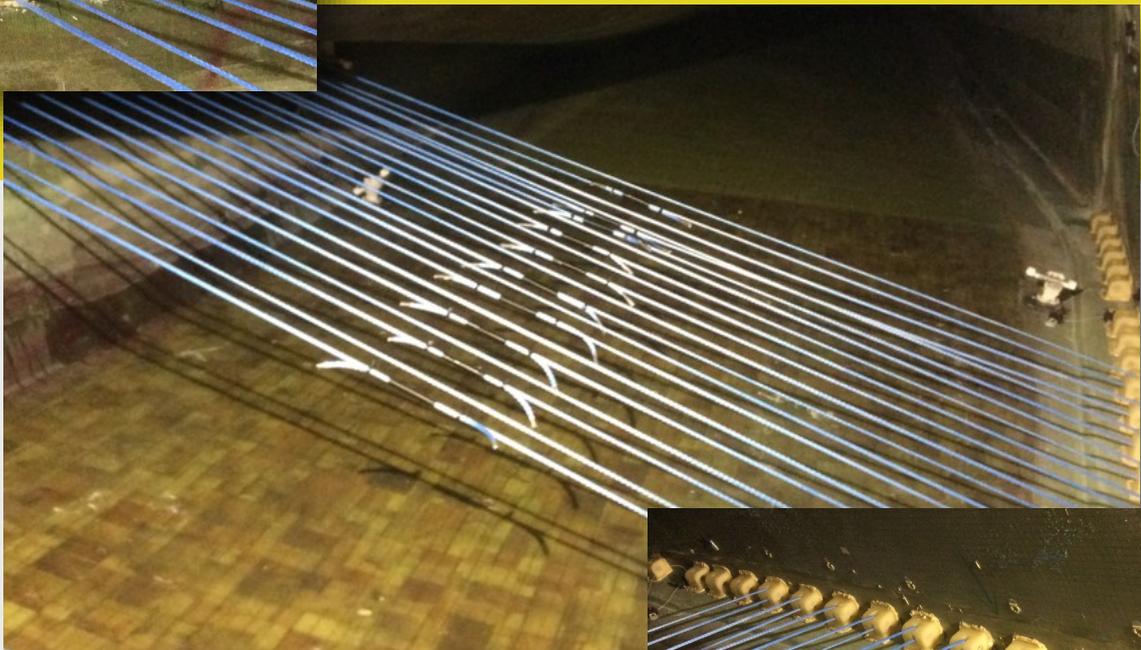
Prevents TWISTING of the main- and rear box of the blades.

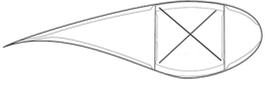
The X-Stiffener™ is an advanced solution developed to eliminate cracks in the adhesive bondlines of the main box, by removing twisting as the root cause.

The installation of the X-Stiffener™ positively affect the operation of your Wind Turbine.



- 1. The X-Stiffener™ eliminates cracks in the adhesive bondlines in the rear- and main box.**
- 2. The X-Stiffener™ help blades with large flatbacks to avoid excess twisting.**
- 3. The X-Stiffeners™ help to stabilize the main box and thereby maintain the aerodynamic profile of the blade.**
- 4. The X-Stiffener™ significantly increase the anticipated lifetime of your blades.**
- 5. The installation of X-Stiffeners™ does not affect the integrity of your blade.**





X-Stiffener™ Technical Description

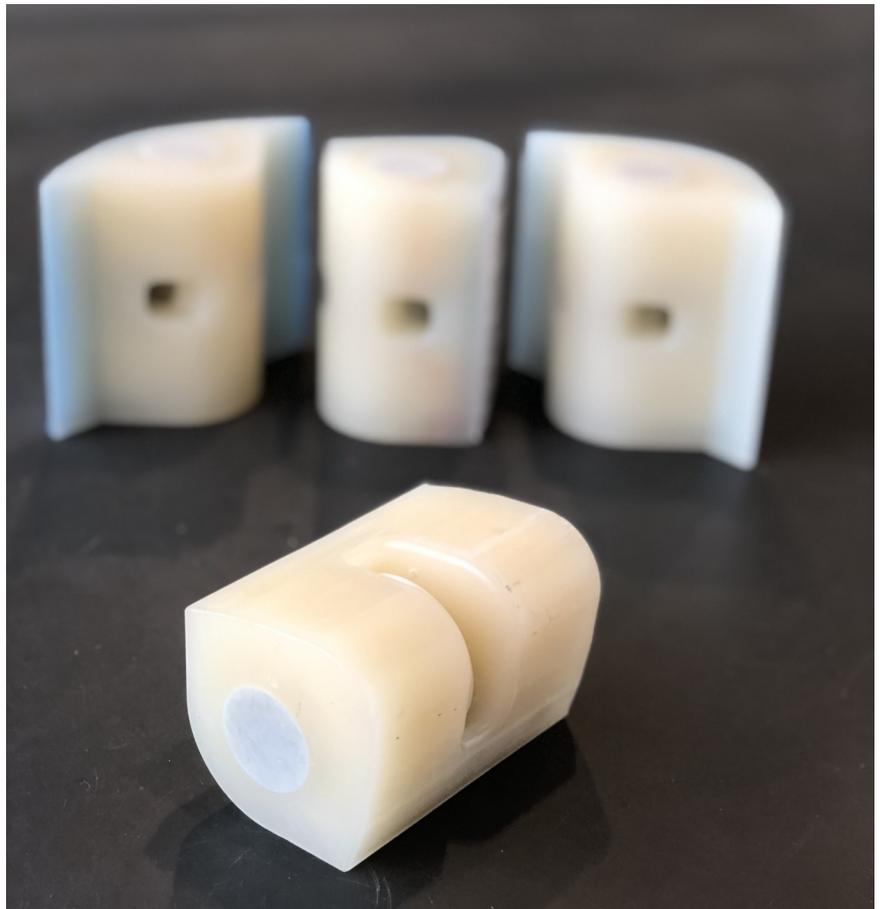
The X-Stiffener™ consists of two components; The anchoring devices and the fiber ropes connecting the corners within the blade.

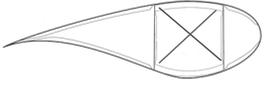
The X-Stiffener™ is designed as a strong yet light weighted product, which consists of respectively an anchoring device and a dynamica DM20 pre-stretched rope. The anchoring device is attached in the corners of the rear- or main box of the blade forming a cross.

The two diagonals attach the corners of the rear- or main box, thereby removing excess movement of the structure: stabilizing the whole blade.

X-Stiffener™ product

The X-Stiffener™ has been developed during the last four years and has been thoroughly tested at the Danish Technical University.





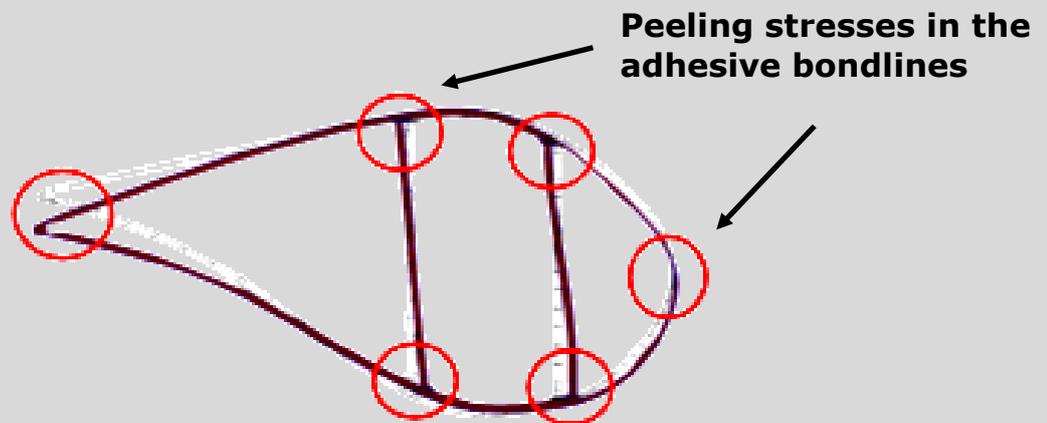
The X-Stiffener™ prevents failures related to twisting

The X-Stiffener™ eliminates twisting in the main box by increasing the cross sectional strength of the blade. FEM modelling shows a 80-85% reduction of twisting after the installation of the X-Stiffener™.

During operation twisting of the main box, increases the peeling stresses in the adhesive bondlines of the blades, as can be seen in the sketches below. The stress concentration in the adhesive bondlines will, if not discovered, develop into cracks, which in time becomes visible on the exterior surface of the blades.

The twisting increases with the length of the blade. A simple comparison between a 34m and a 68m blade showed an increase of more than 250%.

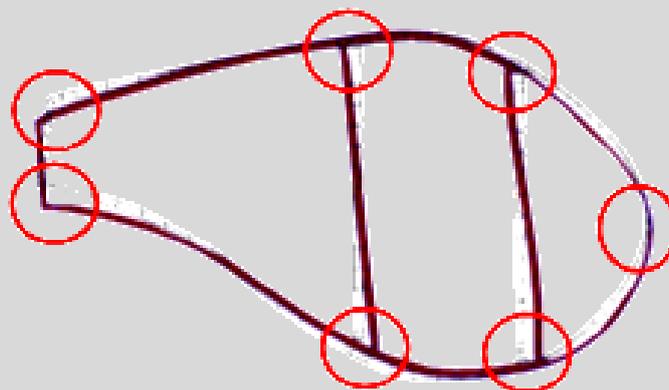
Traditional Design



Flatback Design

White Deformed Shape

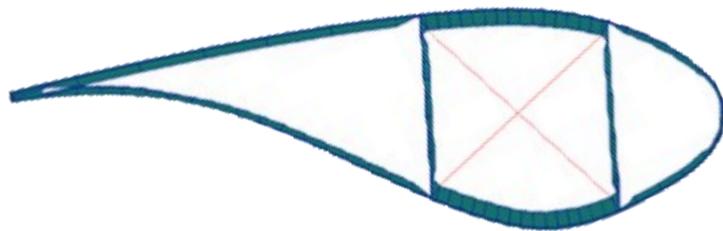
Purple Undeformed Shape



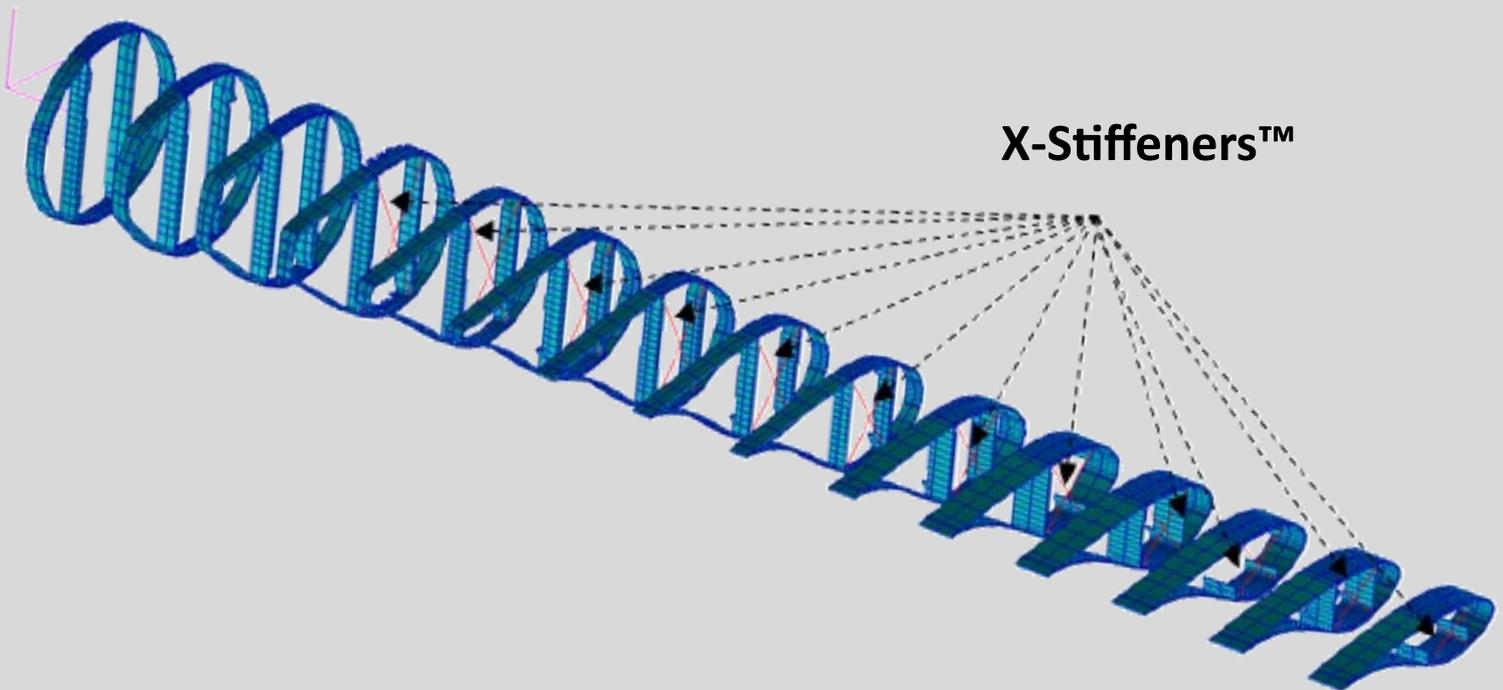
The X-Stiffener™ prevents twisting

The anchoring devices are glued into the corners of the main- or rear box, a non invasive installation. The rope is installed with pretension to sustain the loads during operation.

The pretension of the rope is added with a smart pretensioning system, thereby avoiding any metal parts in the blade.



The X-Stiffeners™ was found to support the rear – or main box during normal operation, thereby avoiding damage of the blades.



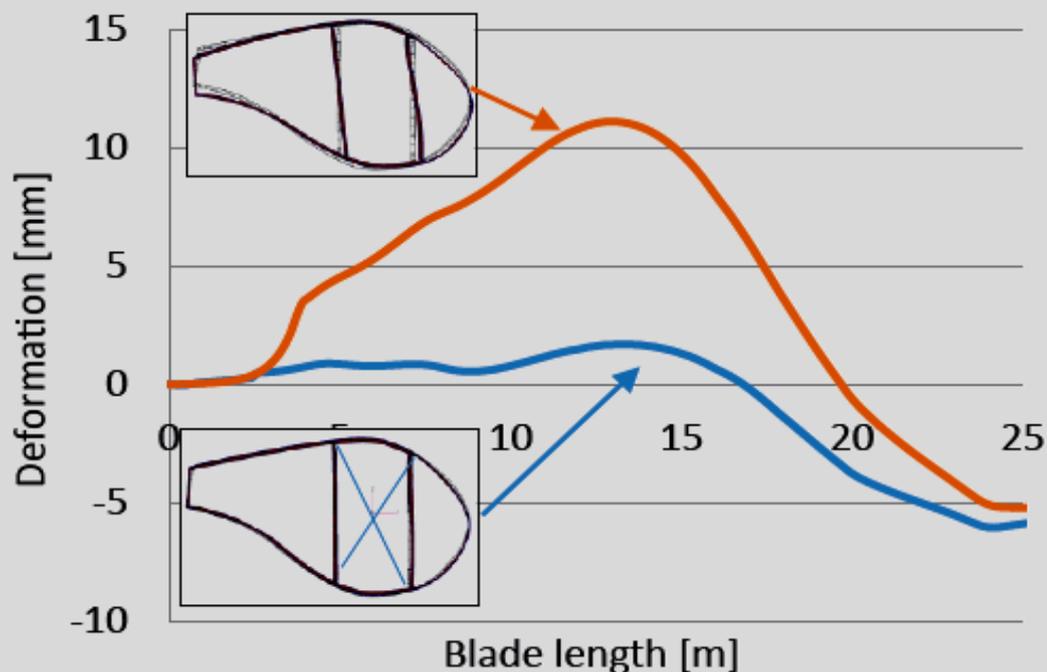
The X-Stiffener™ prevents twisting in the main- and rear box of blades with a large flatback

Blade with a flatback design experience twisting in both the rear as well as in the main box, as seen on regular blades.

Therefore blades with a flatback design benefit from the installation of X-Stiffeners™ in either the rear or main box or in both.

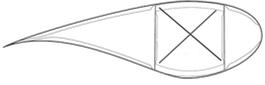
In FEM studies of blades with large flatbacks the deformation of both the rear- and main box was significantly reduced by the installation of the X-Stiffener™.

X-Stiffeners™ reduce deformation in blades with large flatback



— X-Stiffener™ installed — no X-Stiffener™

68m blade with a flatback design



Test program

The X-Stiffener™ is a game changing solution in the market, based on a thoroughly tested technology.

The X-Stiffener™ was matured during the LEX and X-DOF projects, funded by EUDP, and thoroughly tested in both large-scale and sub-component tests.

Static- and Dynamic Tests

The X-Stiffener™ components were tested individually and sub-assembled. All components have been tested statically and in fatigue to measure the peeling stresses in the adhesive bondlines of the blades.

X-DOF Project

From January 2017 until June 2019 the X-Stiffener™ is fully developed for field demonstration on a 7MW offshore turbine. The objective is to reduce Cost of Energy.

Partners in the EUDP: Bladena, DIS Engineering, Total Wind, DTU Mechanical Engineering,

Collaboration Partners in the EU-Demo project from UK, Holland and Spain: Catapult, TNO, Aerox, Siemens Gamesa



References

Field installation

May 2019 installation in 7MW Levenmouth turbine by GEV.

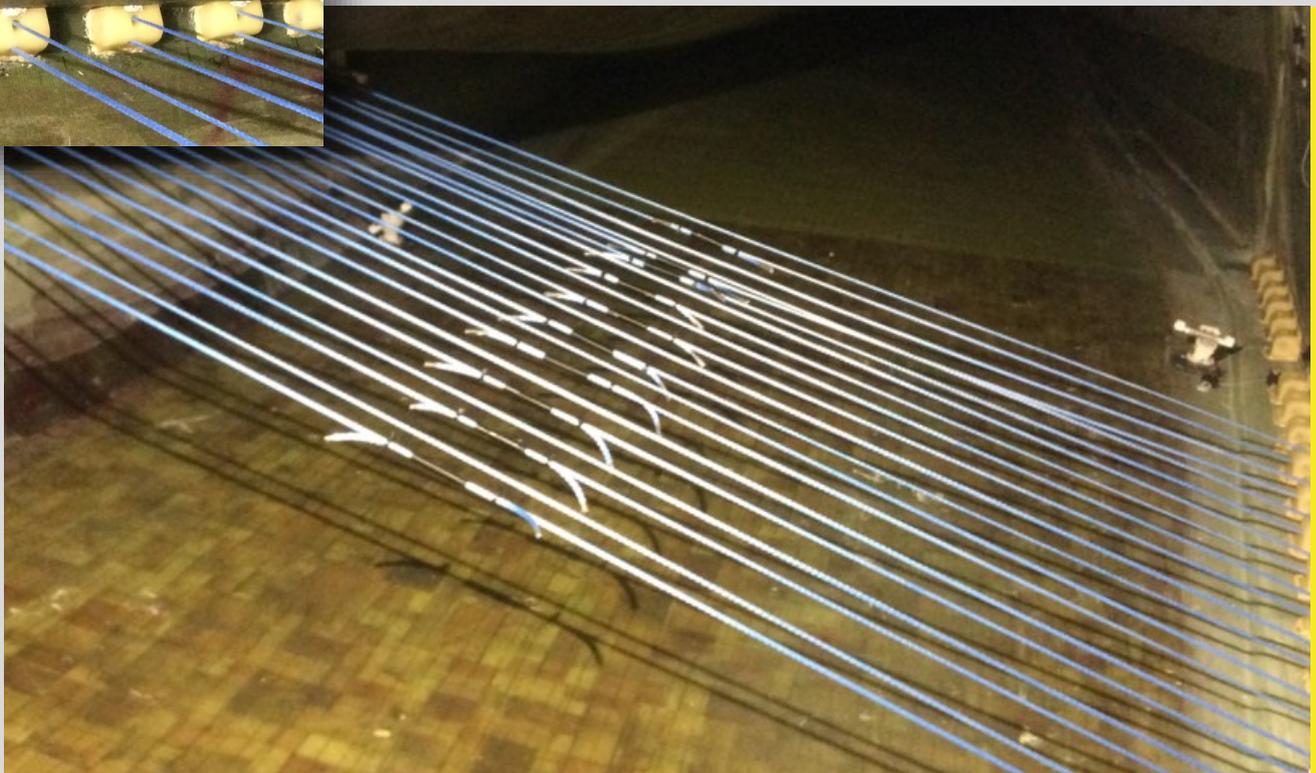
Full-Scale Test

In the summer 2016 the X-Stiffeners™ was installed in a full-scale test at Blaest test centre for fatigue testing in a SSP34 blade.

Large-Scale Test

The full assembled X-Stiffeners™ were tested at the Danish Technical University in a large-scale test during the spring 2016.

X-Stiffener™ - final installation in the 7MW Levenmouth turbine



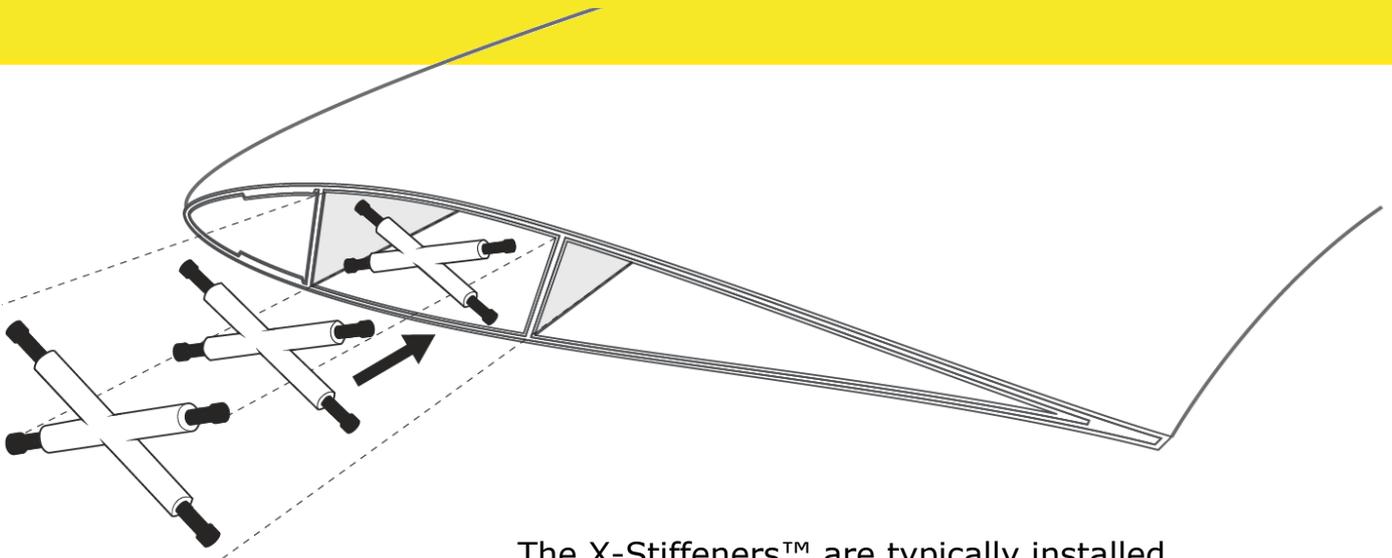


Easy up-tower installation

The X-Stiffener™ can be installed up-tower or installed in new design of blades.

The X-Stiffener™ are glued into the corners of the rear- or main box.

Bladena assists with the installation of the X-Stiffeners™ and works with a network of independent service providers who ensures a reliable and cost-effective installation meeting the highest standards of safety and quality.



The X-Stiffeners™ are typically installed around the max chord depending on the blade.

Bladena performs root cause analysis of your blade and provide the correct placement of the X-Stiffeners™ depending on the problem.



Operation and Maintenance

Installation of the X-Stiffener™ will positively impact the operation of your wind turbines by:

1. Decreasing time for maintenance. This in turn reduces the LCoE increasing profit margin.
2. The X-Stiffener™ is a commercially viable solution that eliminates the occurrence of cracks on aging blades.
3. The X-Stiffener™ secures operation of the blade in the anticipated lifetime of the turbine without added maintenance cost.



Aging blades has an increasing demand for repairs due to cracks. The increasing demand for repairs corresponds to the end of warranty period; therefore the cost of repairs become a liability to the Wind Turbine Owners (see the figure below).

To secure your asset, it is therefore beneficial to install the X-Stiffeners™ before the end of warranty to ensure cheap and easy operation going forward.

Failure Rates



The X-Stiffener™ by Bladena enhance your blades by eliminating twisting of the main and rear box.

Avoiding cracks increase profit margin and decrease time for maintenance.



The X-stiffener™ has a significant positive impact on the anticipated lifetime off your blades.

The X-Stiffener™ decrease the LCoE thus increasing the profit margin.

The X-Stiffeners™ help to maintain the aerodynamic profile of the blade.

Want to talk more about your blades?

Simply contact Bladena

X-Stiffener™

Contact Bladena
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bladena.com