# STATIC TESTING OF CROSS-SECTION OF WIND TURBINE BLADE

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## ABSTRACT

Many modern wind turbine blades are constructed with a load-carrying box girder that supports the outer shell. The purpose of the box girder is to give the blade sufficient strength and stiffness, both globally and locally. Globally, the blade should be sufficiently stiff in order not to collide with the tower during operational loading. Locally, the box girder, together with the stiffness of the outer shell, ensures that the shape of the aerodynamic profile is maintained.

The pressure and gravity load on the blade results in edgewise and flapwise bending, as well as torsional loading of the blade. The box girder primarily carries the flapwise and torsional loads, while the edgewise bending is carried mainly by strengthening the leading and trailing edges of the aerodynamic profile. In flapwise bending, one side of the box girder is in compression and one side in tension. The compressive loading may cause the flange to fail in buckling. It is well known that the boundary conditions have a large influence on the buckling strength of a panel. For the box girder, the transverse properties of the corner and web represent the boundary condition of the flange. The purpose of the investigations presented here is to measure transverse properties of a box girder experimentally in order to investigate how well different finite element models predict these transverse properties. This is expected to result in recommendations for how buckling of wind turbine blades can be predicted using FEM. Comparison between shell and solid FE-models has previously been done by Pardo & Branner [1] assuming isotropic material.

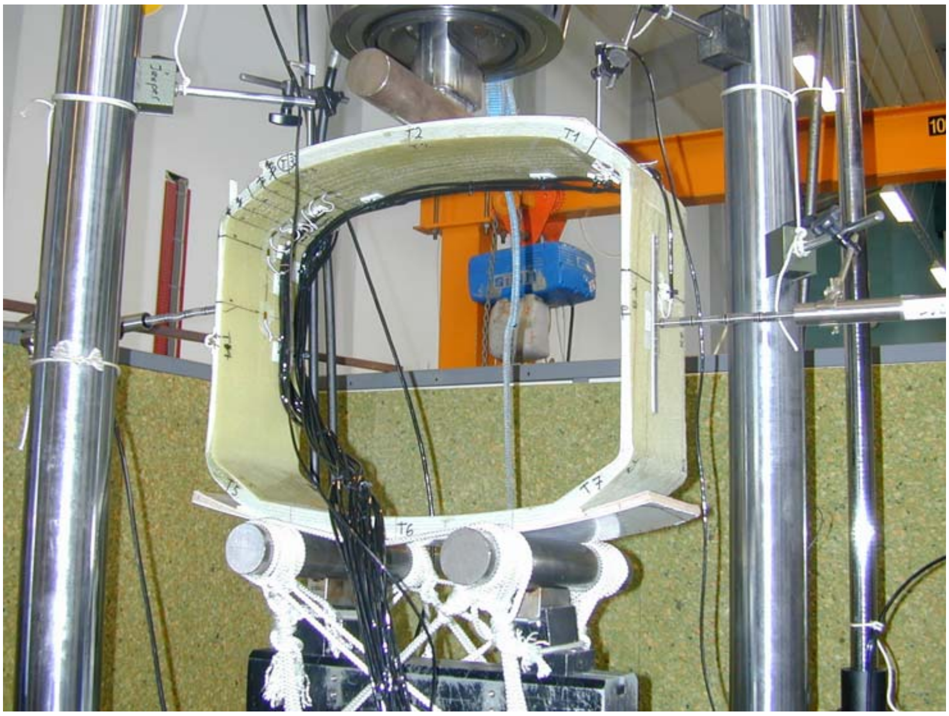


Figure 1 - Test setup. The top is fixed and the bottom with the two supports is moving upward during loading.

The tests are performed in displacement control using a 250 kN Instron material testing machine. The test setup is shown in Figure 1. The upwind side (bottom flange) is supported by two cylinders symmetrical about the midplane. The downwind side (top flange) is loaded by a cylinder in the midplane. Both the support and loading cylinders are slightly angled in order to account for the longitudinal tapering of the box girder. Three specimens cut from the load carrying box girder of a 25m wind turbine blade were tested and deformations and strains were measured. The specimens have different depths, but only little difference is seen for the measurements.

Initial results are reported in Sørensen, Branner et al. [2] and in this paper further results are presented. The overall deformation (actuator load versus travel) of the test specimens is shown in Figure 2. The load per unit depth is normalised with the maximum failure load per unit depth of the 3 specimens. The deformation is normalised with the height of the specimen. The load-displacement behavior of the 3 specimens is very similar. The behaviour is linear up to a deformation of approximately 1% of the specimen height. Geometrical non-linearities can explain the behaviour up to approximately 2.2% of deformation. Hereafter material non-linearities seem to be taking over.

The specimens were tested until failure and the paper will also present results and observation from the collapse of the specimens. Failure mechanisms that led to the collapse will be discussed.

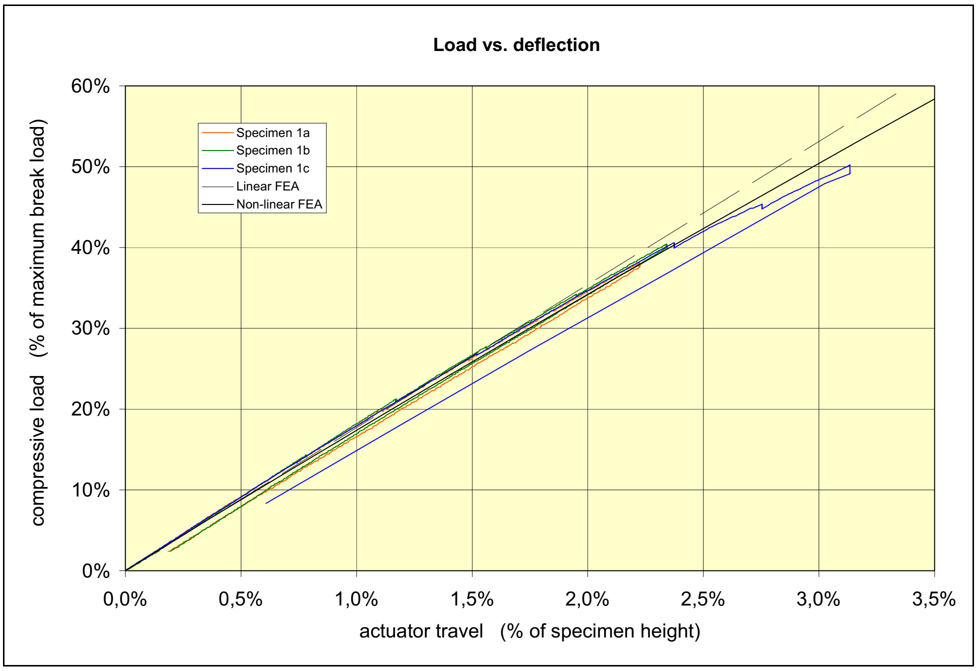


Figure 2 - Actuator load versus actuator displacement for the 3 specimens. The black lines are from the linear and non-linear finite element analysis.

## ACKNOWLEGEMENTS


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## REFERENCES


[1] Pardo, D.R. & Branner, K., "Finite Element Analysis of the Cross-section of Wind Turbine Blades; A Comparison between Shell and 2D-Solid Models", Wind Engineering, Volume 29, No. 1, 2005.

[2] Sørensen, B.F., Branner, K., Stang, H., Jensen, H.M., Lund, E., Jacobsen, T.K. & Halling, K.H., "Improved design of large wind turbine blades of fibre composites (Phase 2) - Summary Report", Risø-R-1526 (EN), Risø National Laboratory, Roskilde, Denmark, 2005.