Ultimate strength of wind turbine blade structures under multi axial loading

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Introduction

The prediction of the effects of the complex states of stress with existing failure criteria can be uncertain and damages and failures often occur earlier than expected. In order to increase reliably and robustly operating wind turbine systems it is of great improatance to predict damage initiation and growth accurately. The purpose of this PhD project is to investigate how multi axial loading effects influence the ultimate strength of typical composite structures in wind turbine blades and to develop methods to perform reliable prediction of failure.

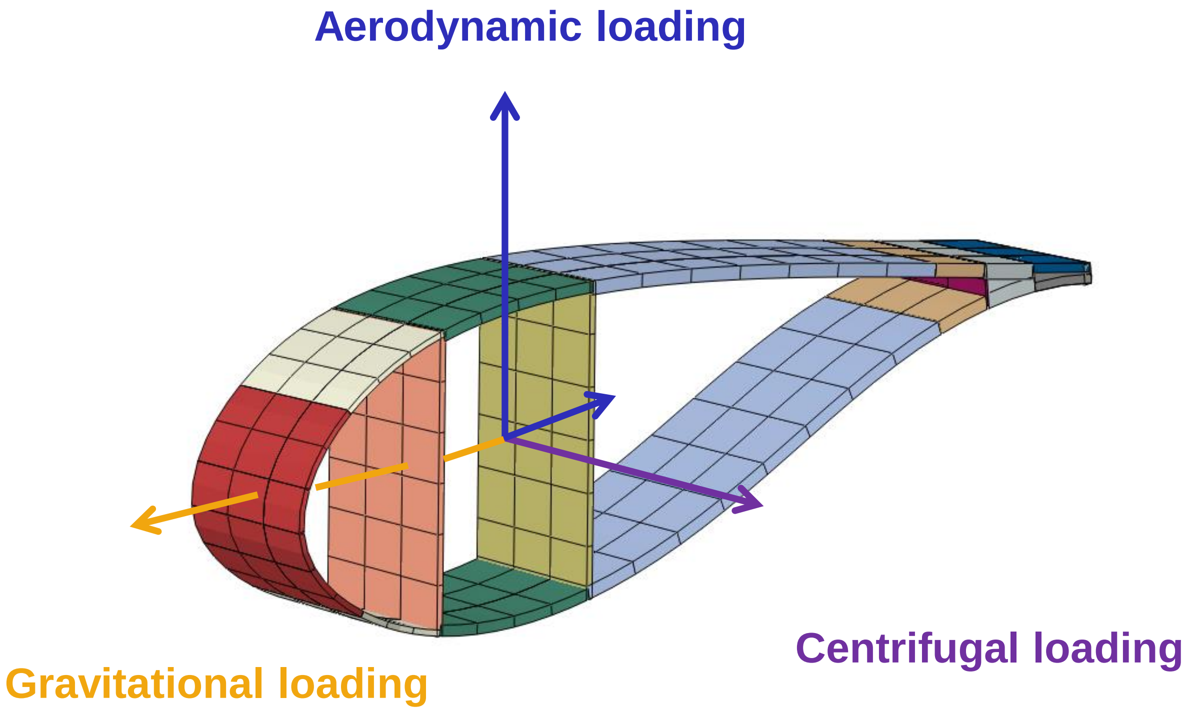

Figure 1: Different types of loads leading to complex and multi axial loading in certain areas of the blades.

Damages in rotor blades

The complex loading of wind turbine blades structures leads to a variety of different damages in rotor blades.

- Adhesive joint failure (type 1 and type 2)
- Sandwich panel debonding
- Buckling driven delamination (type 4)
- Splitting and fracture of laminate structures (type 5)
- Gel-goat cracking (type 7)

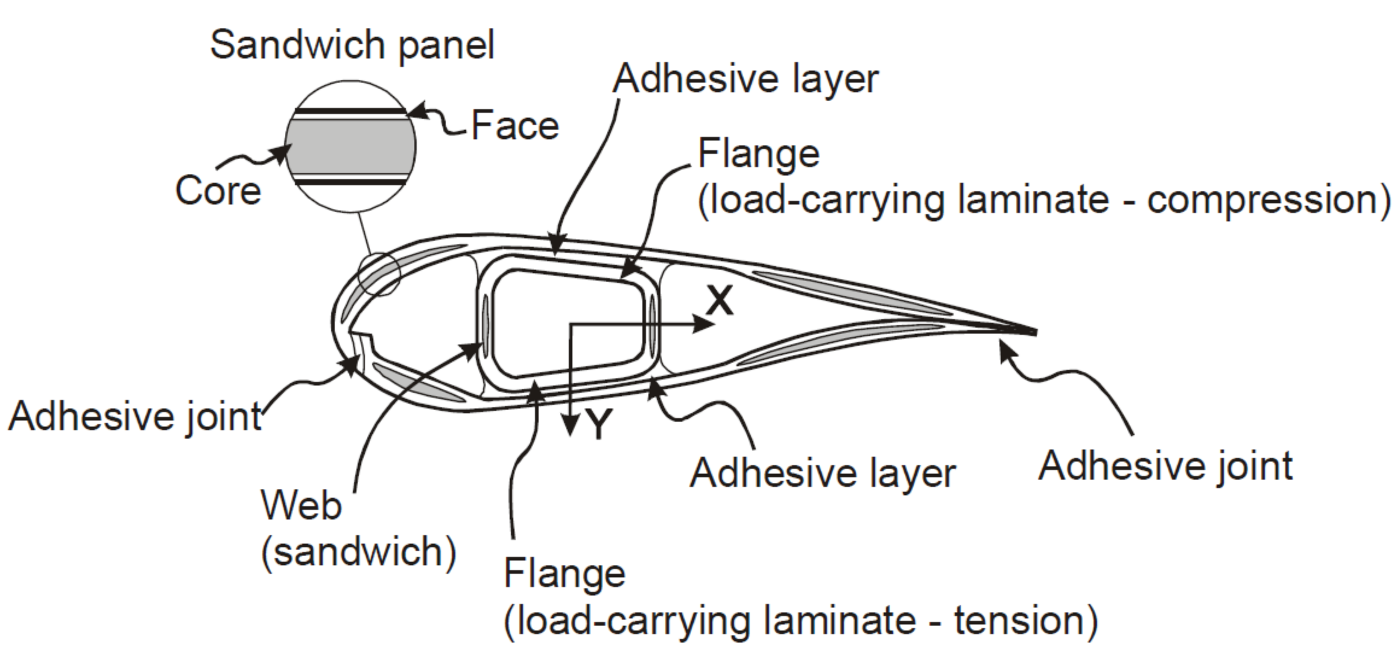

Figure 2: Nomenclature and used materials in a conventional rotor blade structure *[Sørensen, B. F., Jørgensen, E., Debel, C. P., Jensen, F. M., Jensen, H. M., Jacobsen, T. K., and Halling, K. M., 2004. Improved design of large wind turbine blade of fibre composites based on studies of scale effects (phase 1) summary report. Tech. rep., Risø National Laboratory]*.

Approach

The complex loading of wind turbine blades structures subjected to different realistic load cases will be investigated in order to determine most critical multi axial loading spots in the structure.

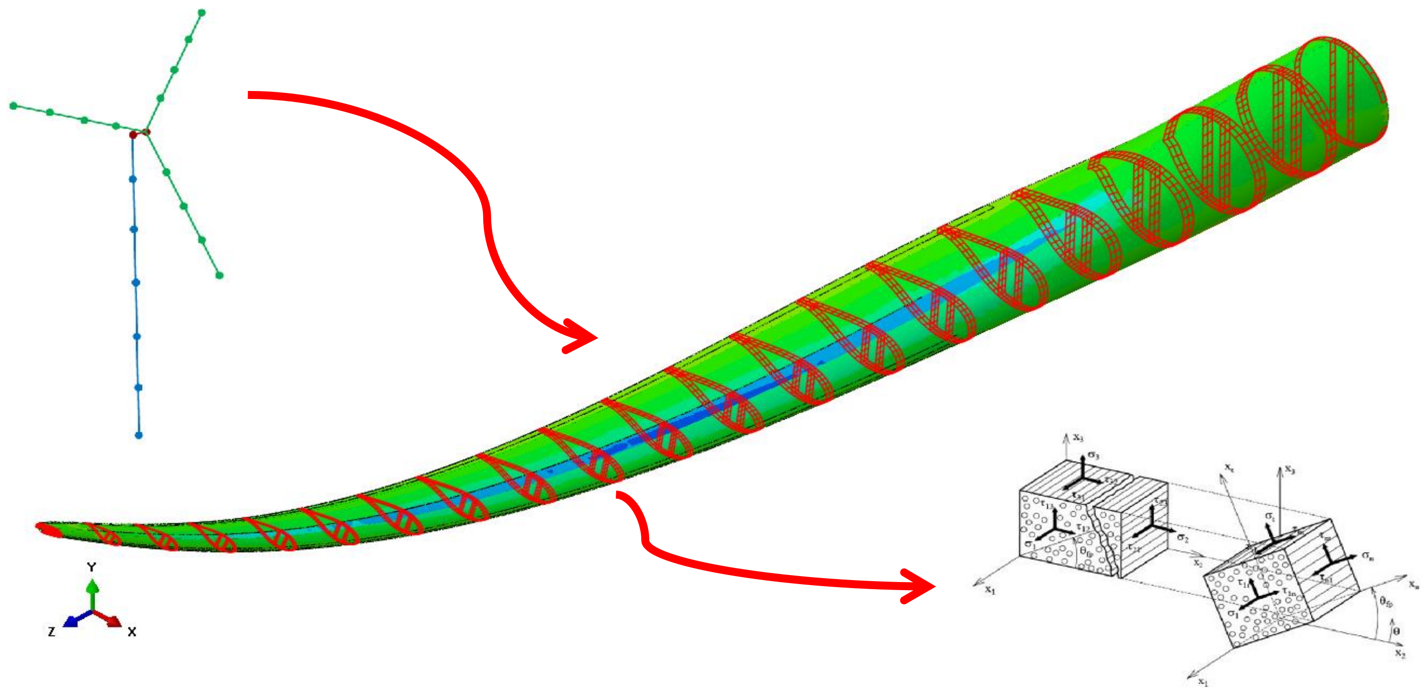

Figure 2: From the aero-elastic simulation to the detailed structural model

The structural analysis will be performed with a finite element analysis (FEA). The load input for the FEA will be created with the in-house aero-elastic simulation code HAWC2. Different IEC 61400 standard load cases for wind turbine rotor blades provide the basis in order to generate realistic load simulations. Different load combinations and hot spots for multi-axial stresses will be compared and evaluated.

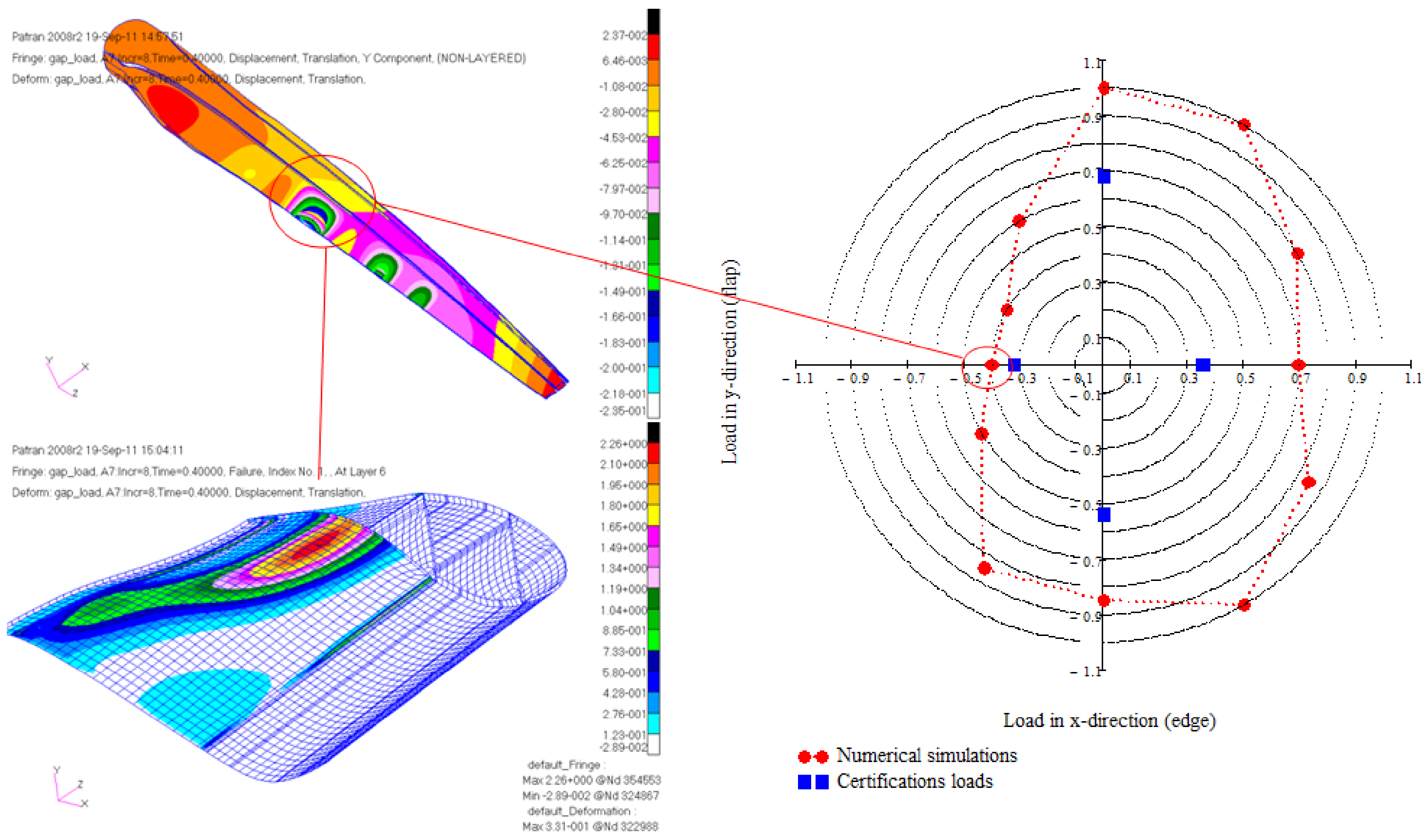

Figure 4: Three dimensional load envelop [Peter Berring, DTU Wind Energy]

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