Blade Manufacturing

Presenter: Theodoros Kossivas

MSc, Mechanical & Aeronautical Engineer, CompBlades founder

Content

- Blade terms and definition
- Aerodynamic design
- Initial structural design
- Aeroelastic calculations
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Blade terms and definition/ HAWT types

Stall wind turbines (Old machines)

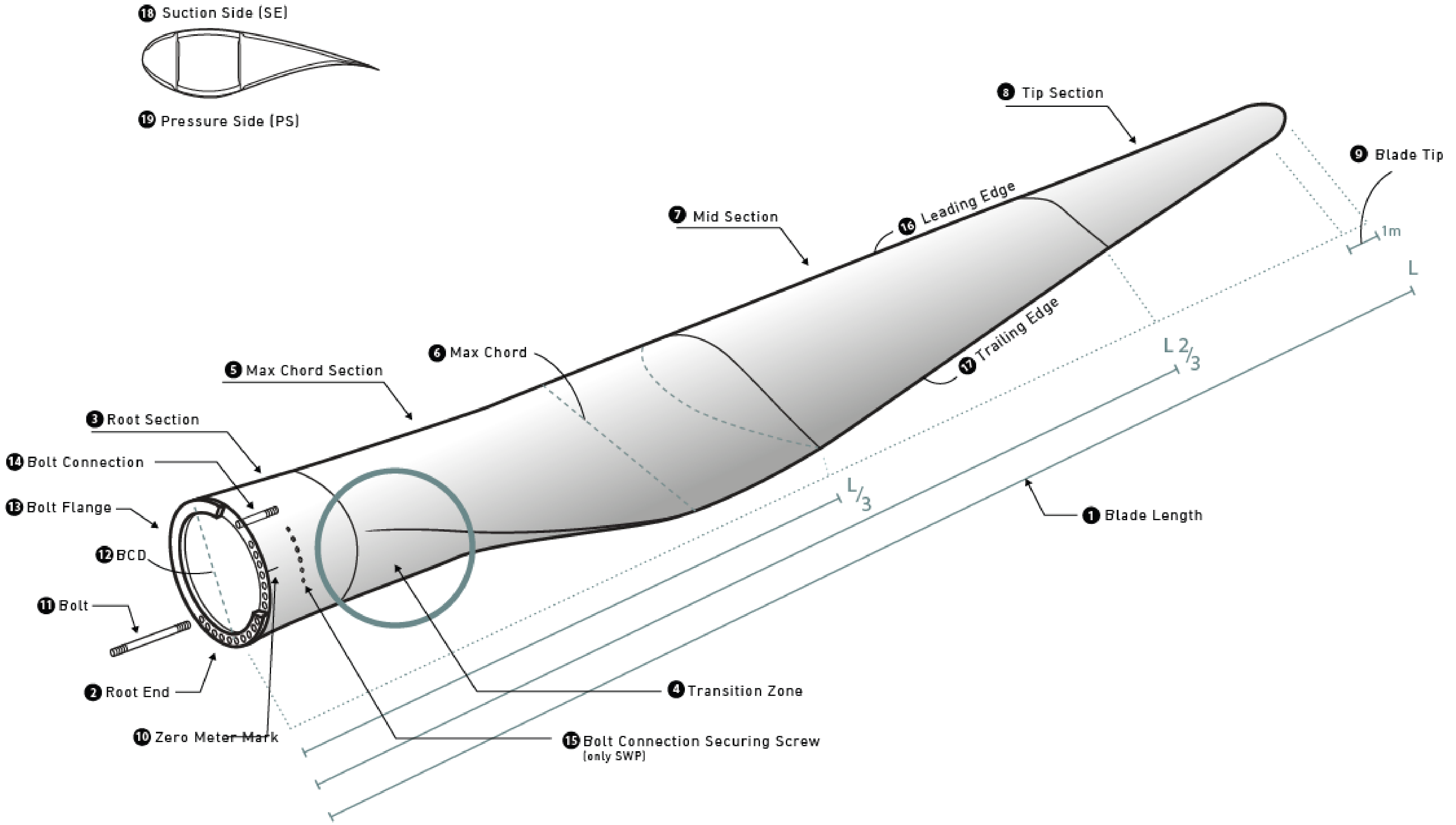
750kW stall machine

Pitch wind turbines (Current machines)

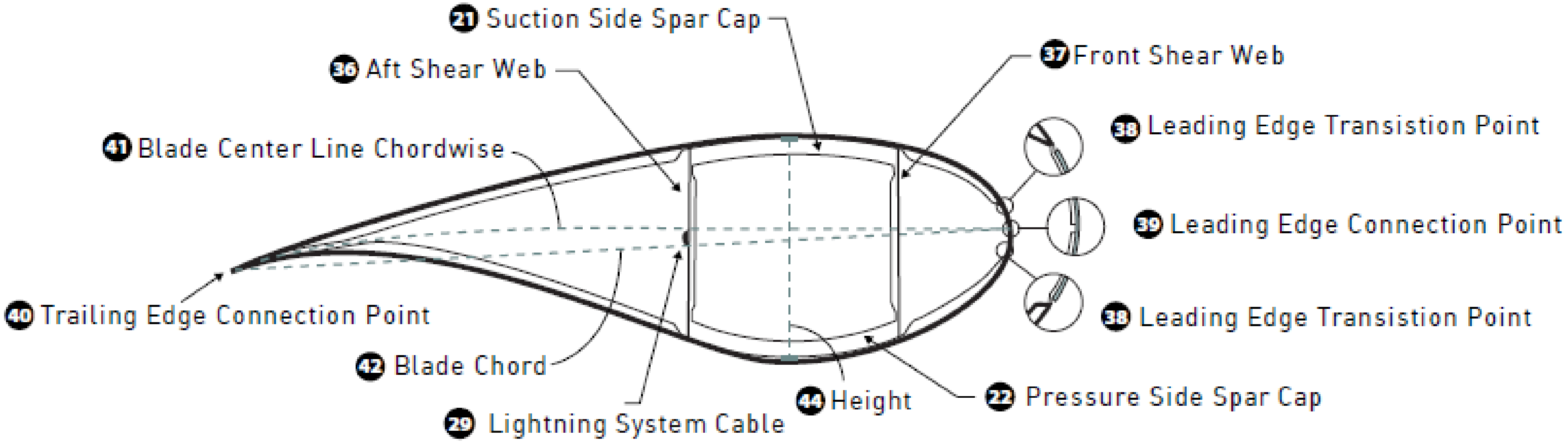
Blade is pitched 0° - Normal operation

Blade is pitched 90°

Blade terms and definition/ Blade regions



Blade terms and definition/ Section



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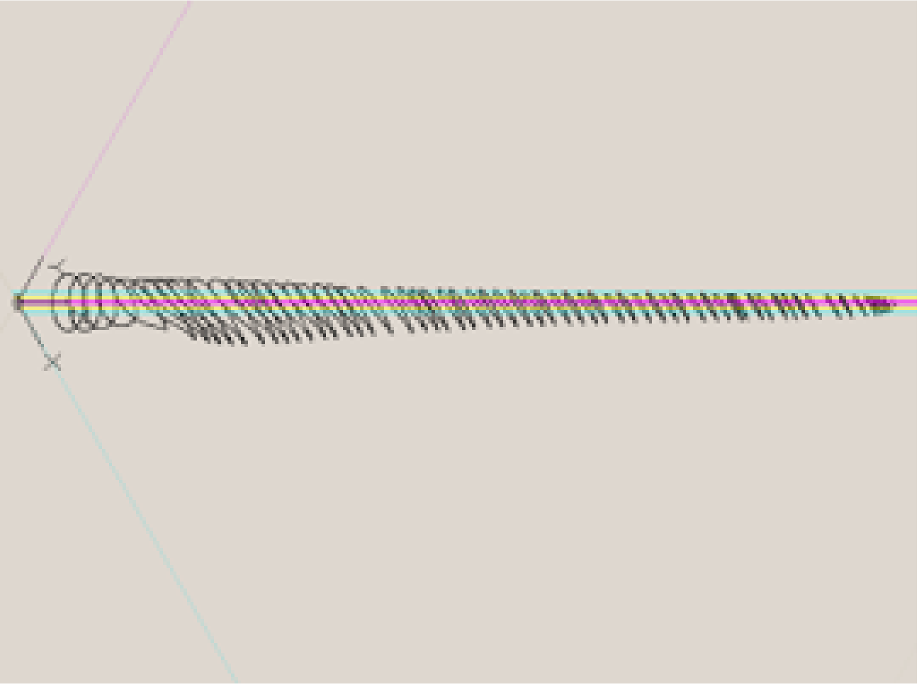
Aerodynamic design / Blade Geometry

- The aim is to design the optimum aerodynamic shape for energy capture and simultaneously meet all the necessary constrains

Airfoil



Airfoils

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Initial structural design

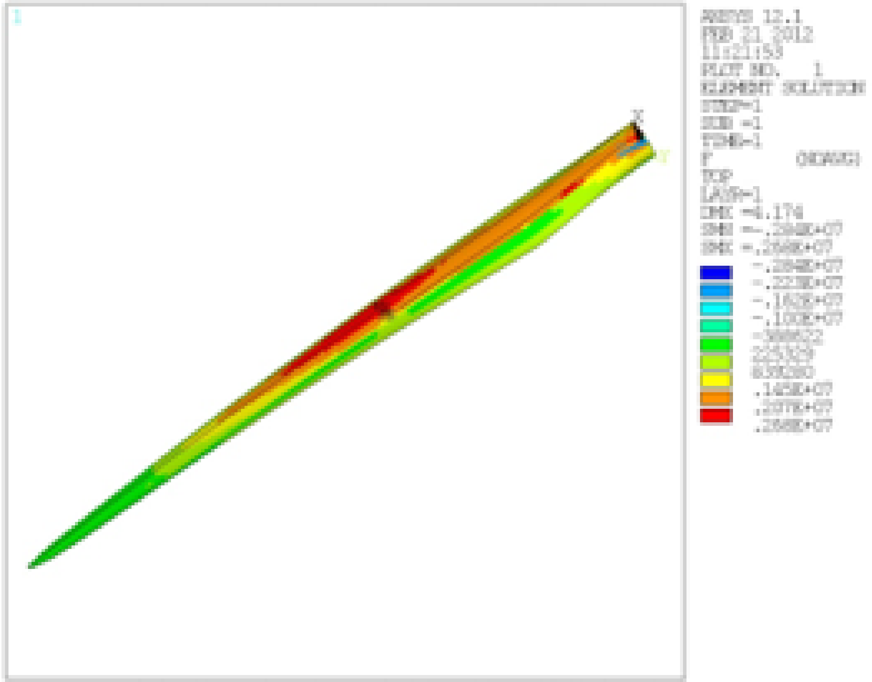
- Mechanical testing to determine the necessary properties for the blade materials. Basic input for the blade design (FEM and sectional tools)

Multiple specimens-coupons for testing

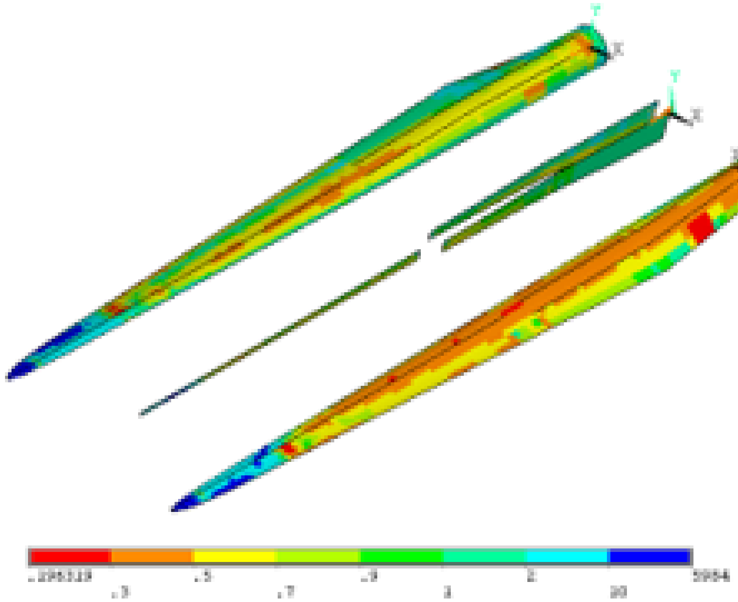
Joint structural part for split blade for tensile testing

Initial structural design

- ''Building'' of blade Finite Element Model to define initial blade mass distribution



AXIAL STRESS RESULTANT



FAILURE CRITERION CONTOUR PLOTS OF 30 METER BLADE DESIGN FE MODEL

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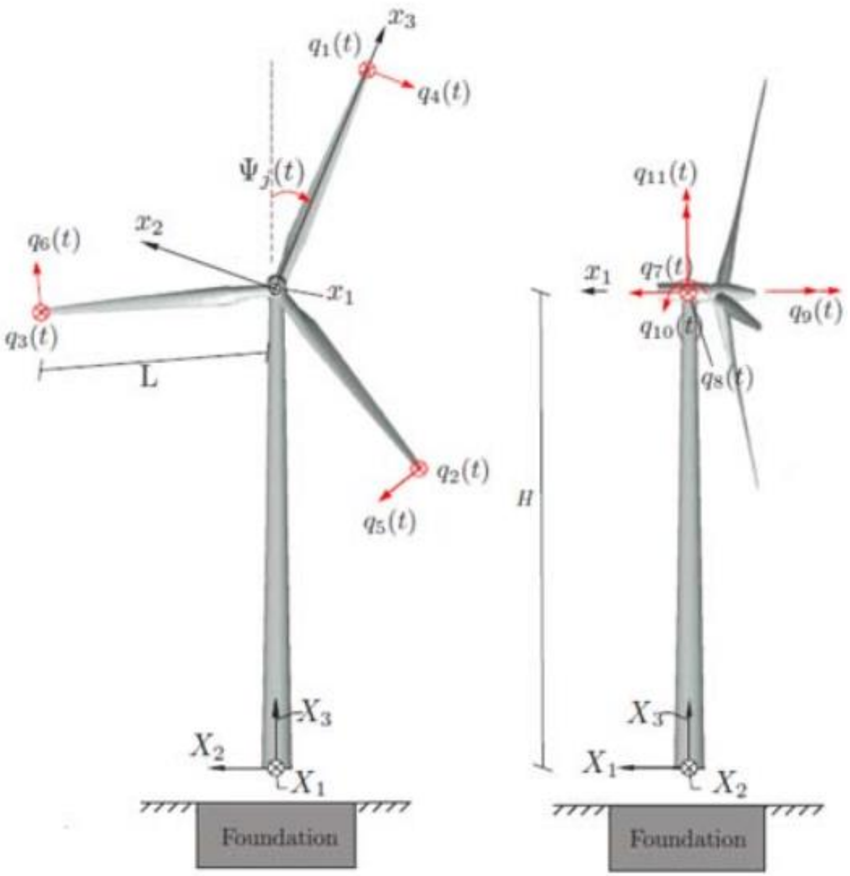
Aeroelastic calculations

- Taking into account the initial mass distribution of the blade are computed the loads per blade section for the load cases defined in IEC 61400 -13



13-DOF aeroelastic model of three bladed wind turbine. Definition of fixed and moving frames of reference and the degrees of freedom.
Source:DOI:10.1088/1742-6596/524/1/012037

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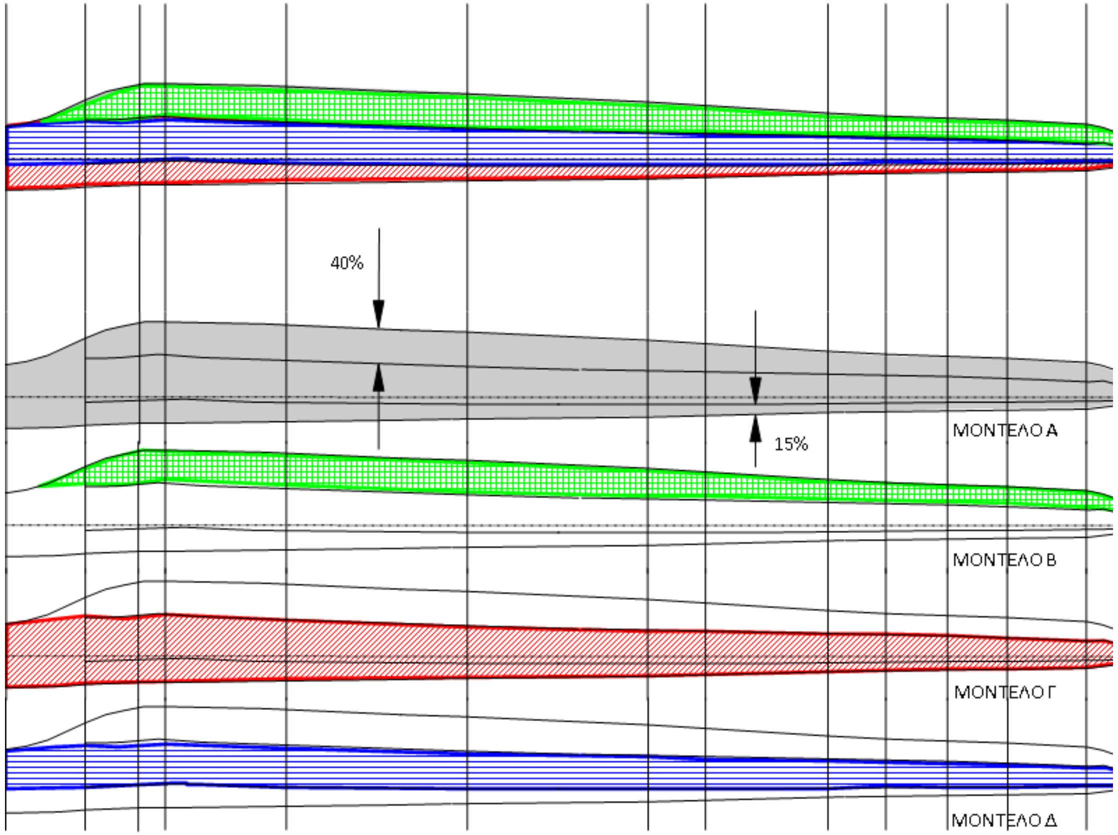
Structural design

Taking into account the loads from aeroelastic study we perform the structural design

Lamination plan – Layup for all the blade load cases according to standards



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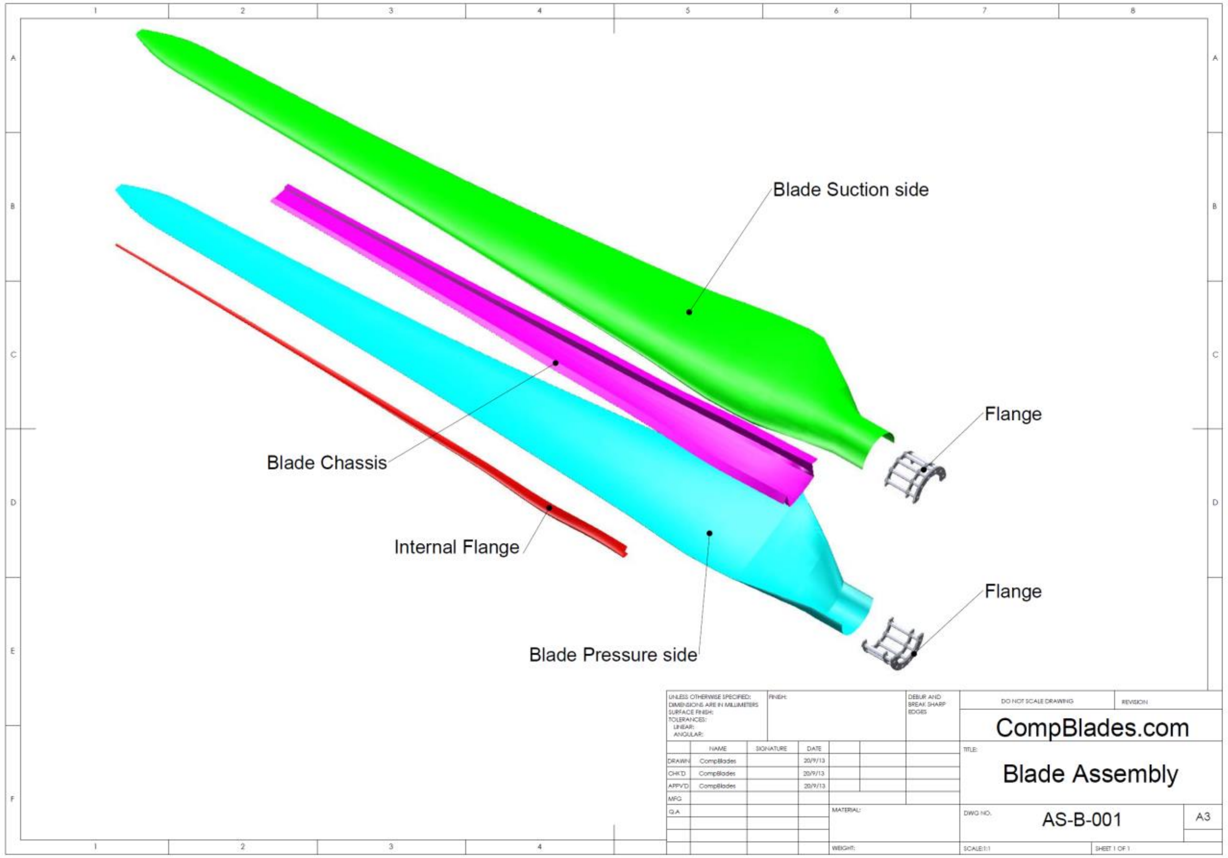
Construction design

- 3-D detailed construction design of the blade, taking into account all the materials and internal metallic parts



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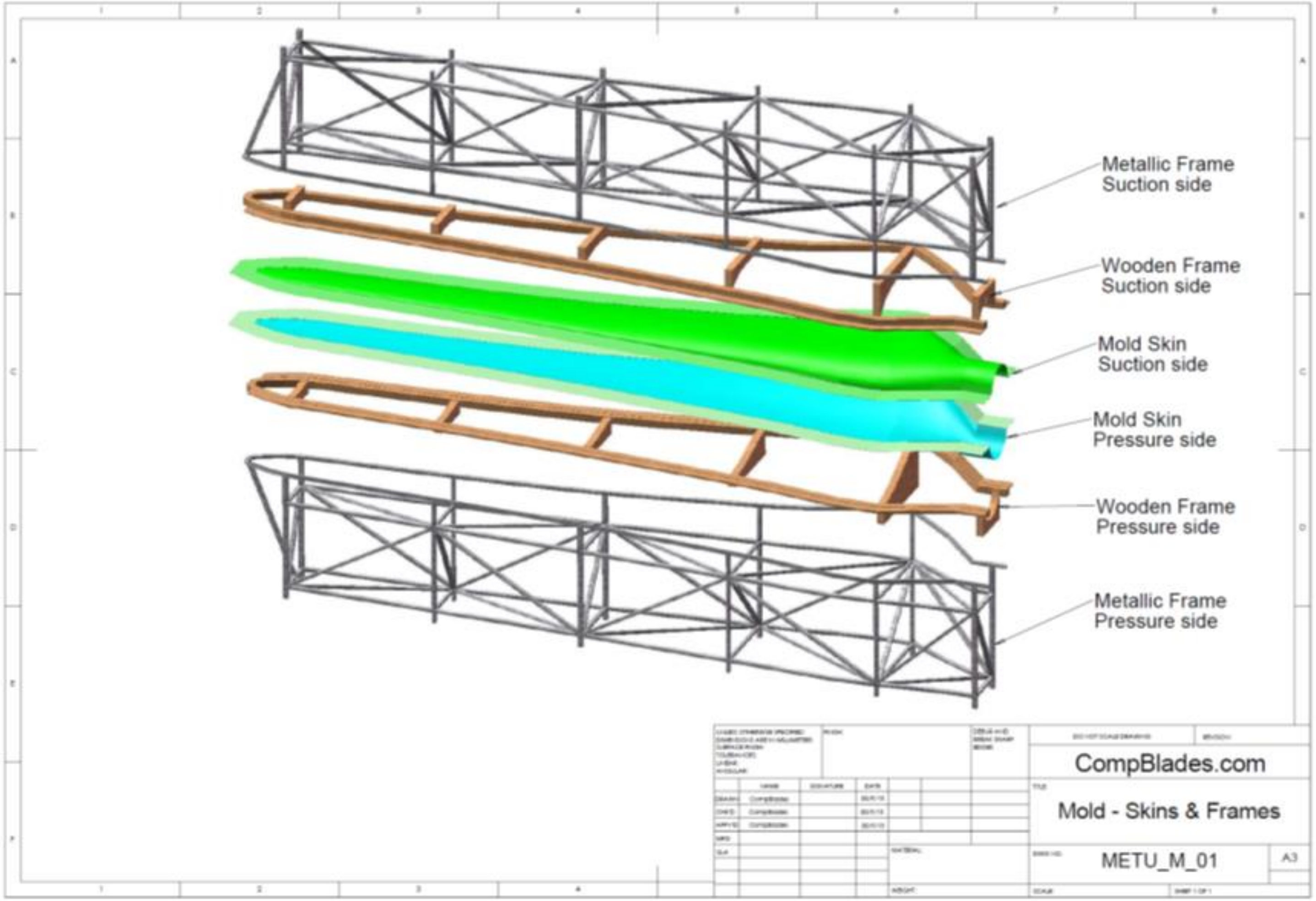
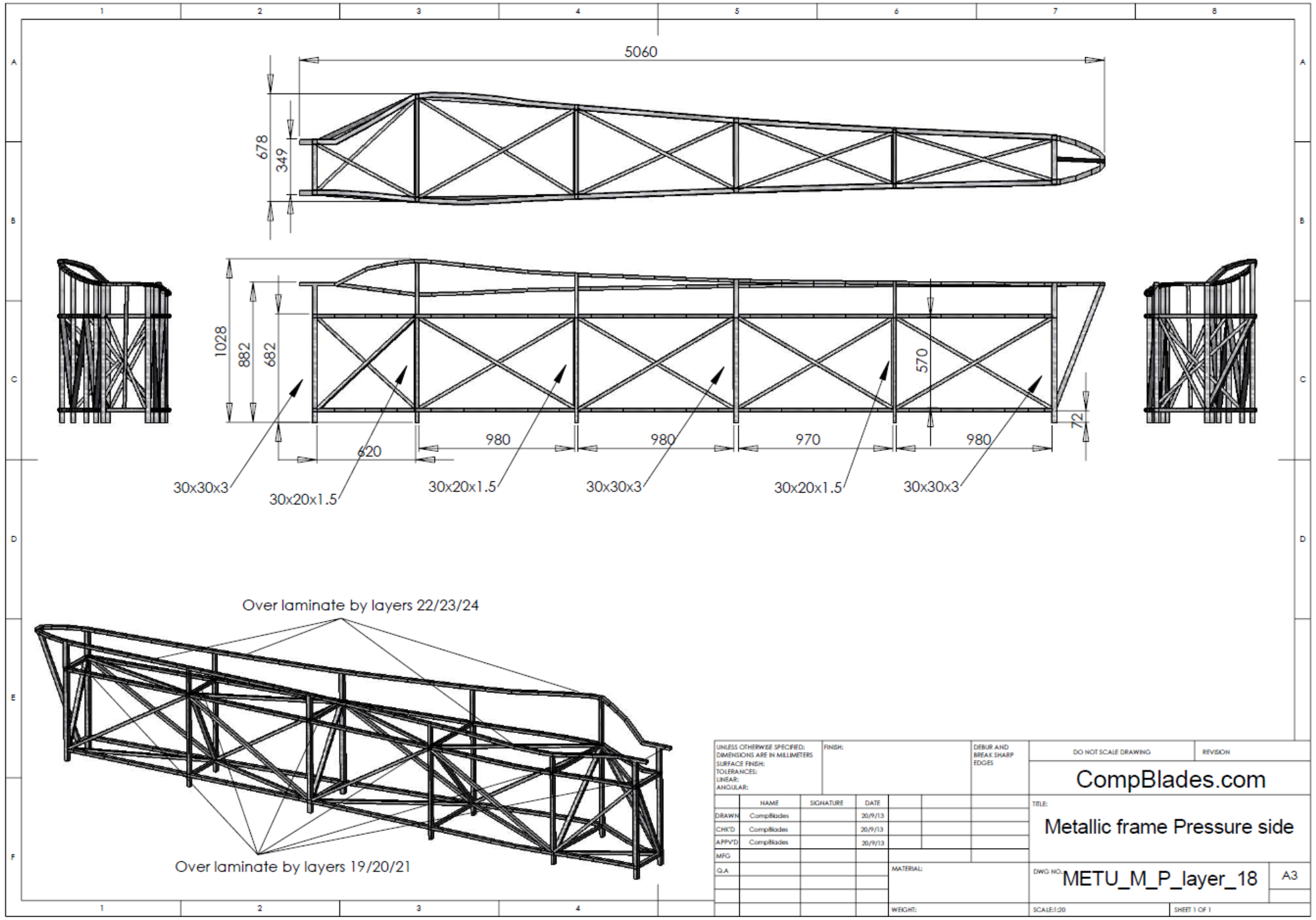
Mold construction for prototype blades

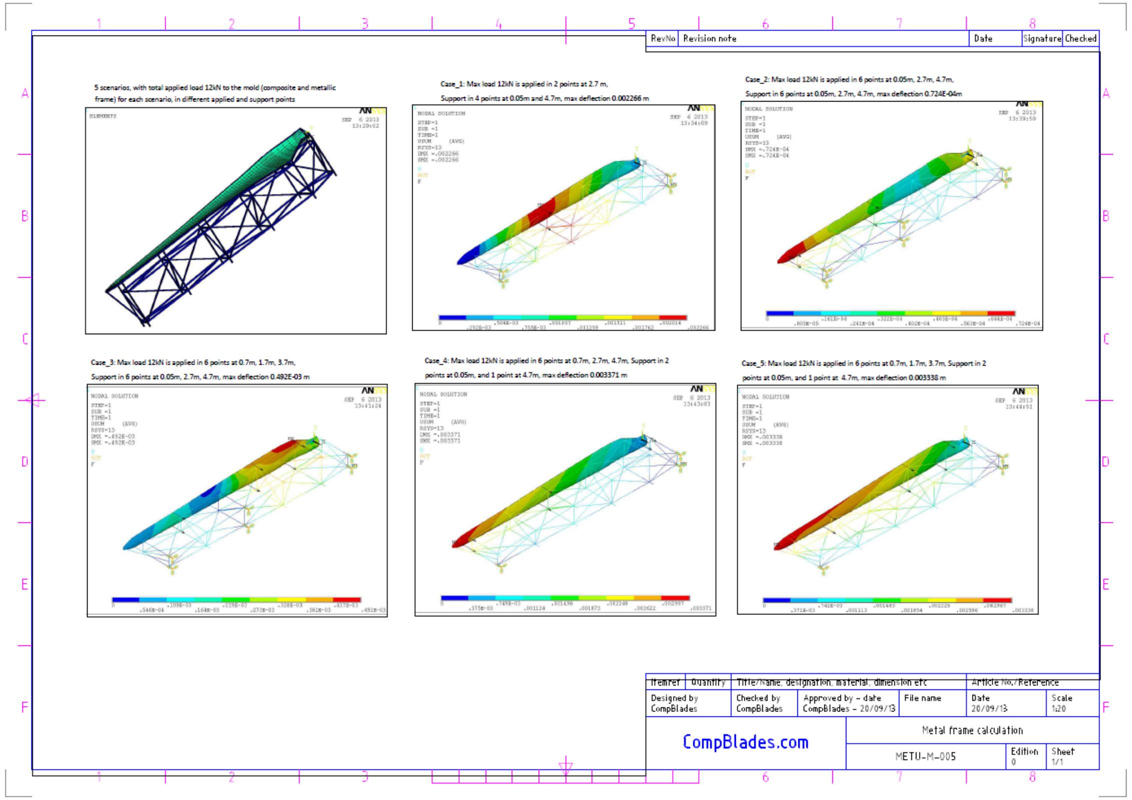


Mold construction for prototype blades / Back structure, metallic frame



Mold construction for prototype blades /

FEM of mold structure to ensure stability and stiffness of the support structure



Mold construction for prototype blades / Plug construction (case study of a 30m split blade at 2001)


Pitch axis


Airfoil


Airfoils have been placed according to the pitch axis


Volumetric filling


Mock-up quality control


CNC technology
Source: CRADA NFE-16-06051
ORNL/TM-2017/290

Mold construction for prototype blades /

Mold construction (case study of a 30m split blade at 2001)

Mold laminate

Mold metallic support frame

Open mold

Mold construction completed

Half mold opening

Picture of Production mold CNC cutting

Source:

https://www.windpowermonthly.com/article/1705890/

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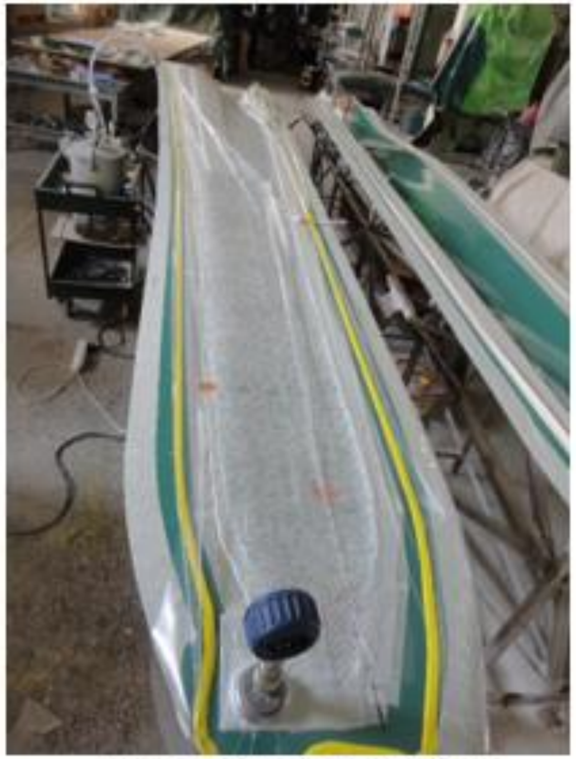
Blade manufacturing

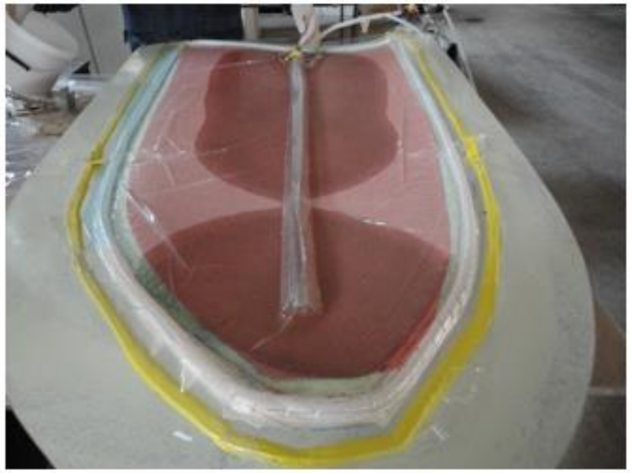

Wet hand lay-up lamination



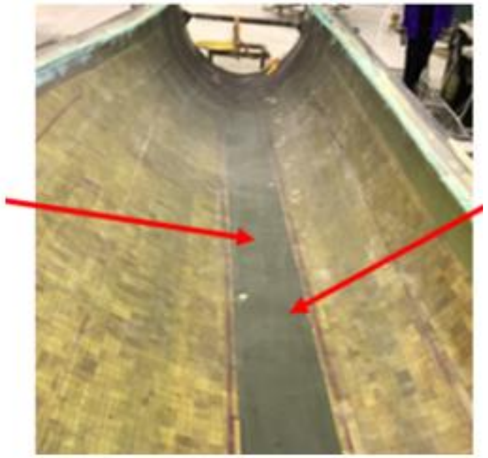
Vacuum bagging technique

Curing process – Polymerization

Blade manufacturing



Vacuum infusion process



Prefabricated spar cap
Source: Ref. Ares(2019)2930281 - 02/05/2019

Assembly of shear webs

Blade manufacturing


Blades have been demolded


Joint of the split blade

Blade manufacturing

Blade construction is completed

Blade manufacturing / stall machines air brake

Air brake – blade tip / Internal shaft for stall machines – filament winding

Blade tips with the internal shaft

Air brake for stall machines

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Blade testing

The blade should be tested under extreme static loads and cyclic loading before approved

30m split at RISO (Denmark) Lab for testing - year 2002

Blade testing

19m blade at CRES lab for testing – year 2000

14m and 4,5m blade at CRES lab for testing – year 2002

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Approved blade structural design

- After blade testing, possible final structural redesign
- Approved final lamination plan and structural design of metallic parts of the blade

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Rotor construction, a set of 3 blades

3 Blades of 19m length, have been balanced and ready to install

Rotor construction, a set of 3 blades

1997: The 1st Greek 9.3m blades during installation on 110kW W/T
CRES wind park at Lavrio

2001: Greek 19m blades installation on Greek 600kW wind turbine
CRES wind park at Lavrio

Rotor construction, type certificate

Wind turbine type certification is **the accreditation, done by a reputable third party ("Certification Body"), that a manufacturer is selling a wind turbine that meet relevant standards and codes**. TUV, DNV-GL, Bureau Veritas (among others) are examples of Certification Bodies.

- Measurement Of Mechanical Loads according to IEC 61400 -13
- Power performance measurements of electricity producing wind turbines according to IEC 61400 -12-1

10 min time series flapwise, edgewise, +/45 bending moments

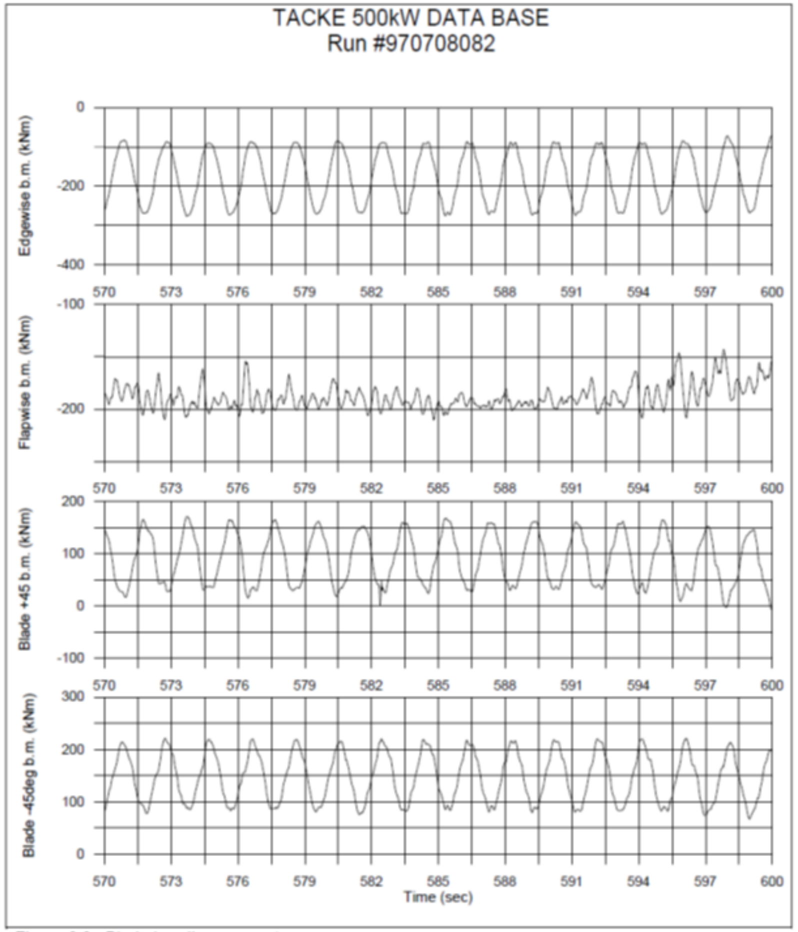

Figure 6.8. Blade bending moments

THANK YOU FOR YOUR ATTENTION

Theodore Kossivas on behalf of

compblades
W/T Blades Repair and Maintenance

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