CENER

CENTRO NACIONAL DE ENERGÍAS RENOVABLES

NATIONAL RENEWABLE ENERGY CENTRE

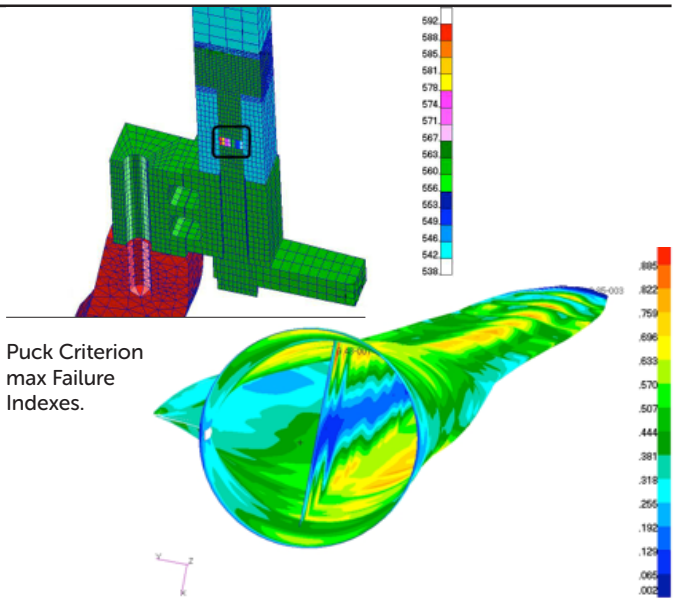
WIND ENERGY DEPARTAMENT

STRUCTURAL DESIGN

BLADE DESIGN

"Towards optimized and reliable designs combining analytical applications with advanced tools...Let's anticipate local failures!"

- In-house analytical applications and advanced tools based on FE analysis are efficiently combined in order to obtain optimized blade structure designs.
- Deep understanding of complex failure modes and local effects: delaminations, debonding, fatigue...
- Full assistance with certification bodies (GL 2010, DNV-DS-J102 2010...).



Puck Criterion max Failure Indexes.

HUB & FRAME DESIGN:

"Our philosophy: Cast-manufacturer friendly designs"

- Manufacturing characteristics and requirements are considered in the design phase, thanks to a close collaboration with manufacturers
- Full assistance with certification bodies (GL 2010, DNV-DS-J102 2010...).

3D Hub FE Model

TOWER DESIGN:

"When design safety factors are extremely conditioned by the geometrical imperfections caused by the manufacturing process..."

- Deep understanding of the structural behaviour of welded and bolted joints.
- Design and evaluation of both bolted and welded joints considering VDI2230 standard and those specialized guidelines defined by the International Institute of Welding respectively.
- Full assistance with certification bodies (GL 2010, DNV-DS-J102 2010...).

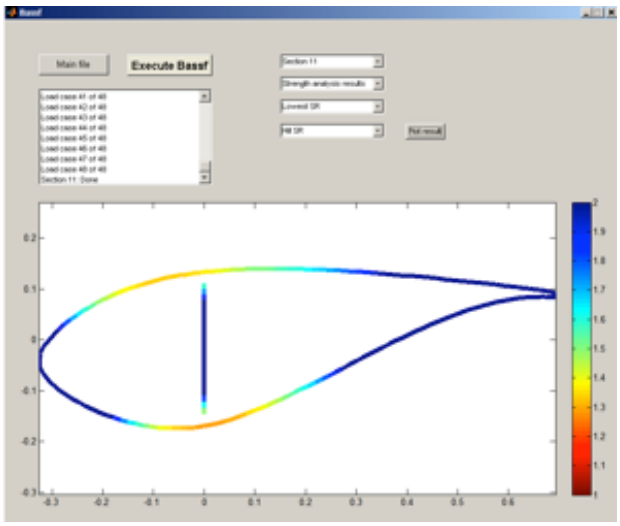
CENER | Ciudad de la Innovación, 7
31621 Sarriguren (Navarra) · España
T + 34 948 25 28 00
info@cener.com · www.cener.com

RESEARCH & DEVELOPMENT:

Rotor blades represent approximately one quarter of the total cost of typical wind turbines. They play a paramount role in key aspects such as turbine efficiency and load propagation. Most commonly used techniques are based on mixed analytical and numerical techniques which try to predict the failure of the rotor blade considering ideal laminates with no defects, but accounting for extremely high design factors. But..., are our models sensitive to the real life?, are they skill-enough to estimate local failures due to complex mechanisms?, have rotor blade designers strong confidence in their designs?... Structural area research lines are focused on the application of rotor blade advanced design techniques (trying to understand local and complex failure modes) challenging the limits of certification. Main research topics are listed below:

BASSF (Blade Analysis Stress Strain Failure):

Tool used in the blade's initial design phase. It is based on analytical formulations such as Euler-Bernoulli & Classical Laminate Theory. Considering the blade aerofoils, the material ply properties and the loads, the user can easily define the internal architecture and laminate lay-up capable to support both static and fatigue loads obtained from an aero-elastic analysis.

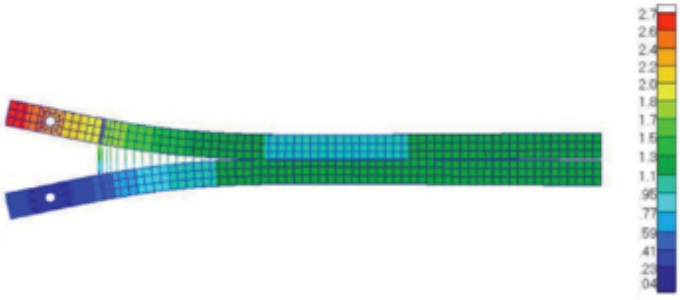


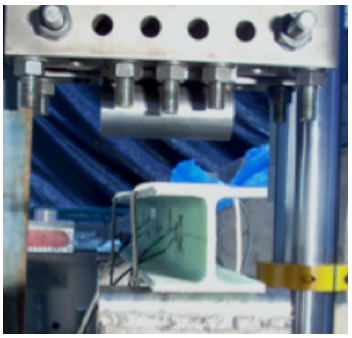
- Capabilities already developed: sectional mechanical properties (including couplings), strength analysis considering most common composite failure theories and fatigue design based on SN approach and CLD curves (direct I/O data communication with GH BLADED).
- Capabilities in development: buckling, stochastic design based on the statistical distribution of load & material properties and user interface improvement.

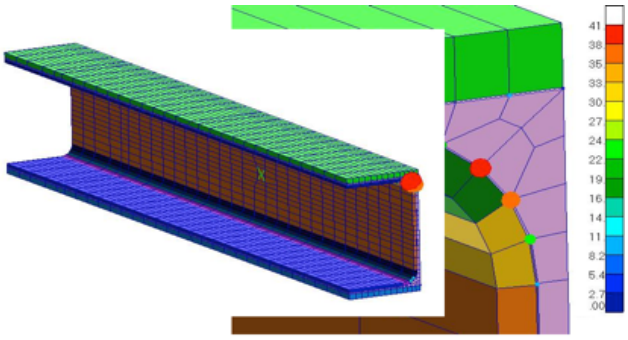
FMAC (Fracture Mechanics Adhesive Calculation):

Tool employed in the detailed design phase of the blade's bonded joints. Its formulation is based on linear fracture mechanics theory, determining whether an initial defect propagates or remains stable. It works together with a FE code (NASTRAN format) enabling the designer to reliably evaluate the capability of a bonded joint to withstand extreme and fatigue loads.

- Capabilities already developed: VCCT theory implemented, first crack automatic generation, crack propagation assessment and direction prediction.
- Capabilities in development: user interface improvement, non linear fracture mechanics integration (cohesive elements, non-linear springs...), validation test campaign with representative components.







FATCOMP (Fatigue on Composites):

From a deep state of the art review of the most advanced fatigue methods, a promising theory based on an innovative connection between micro and macro mechanics has been identified. Based on this approach an R&D project is being executed. The scope of this project includes a validation phase (with potential improvements) of the method, an integration stage of this new theory into the blade design loop by the development of an in-house tool (FATCOMP) and a final evaluation in terms of blade reliability and weight.