Tidal Turbine Blades: Testing and Simulations

Newcastle University (Hassan Izadi, Dr Noushin Moharrami, Dr Adrian Oila and Professor Steve bull)

EPSRC Engineering and Physical Sciences Research Council

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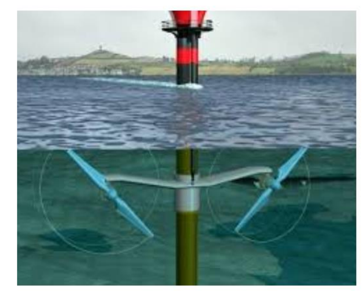
Introduction

➢Tidal turbine blades are subjected to static and cyclic flexural loads by seawater currents.

➢The aim of this study is to investigate the mechanical performance of tidal turbine blades made of composite materials



Experimental

➢ Static and cyclic three point bending tests were performed for a complete characterization of mechanical behaviour of various composite materials Including fibre reinforced and sandwich composites

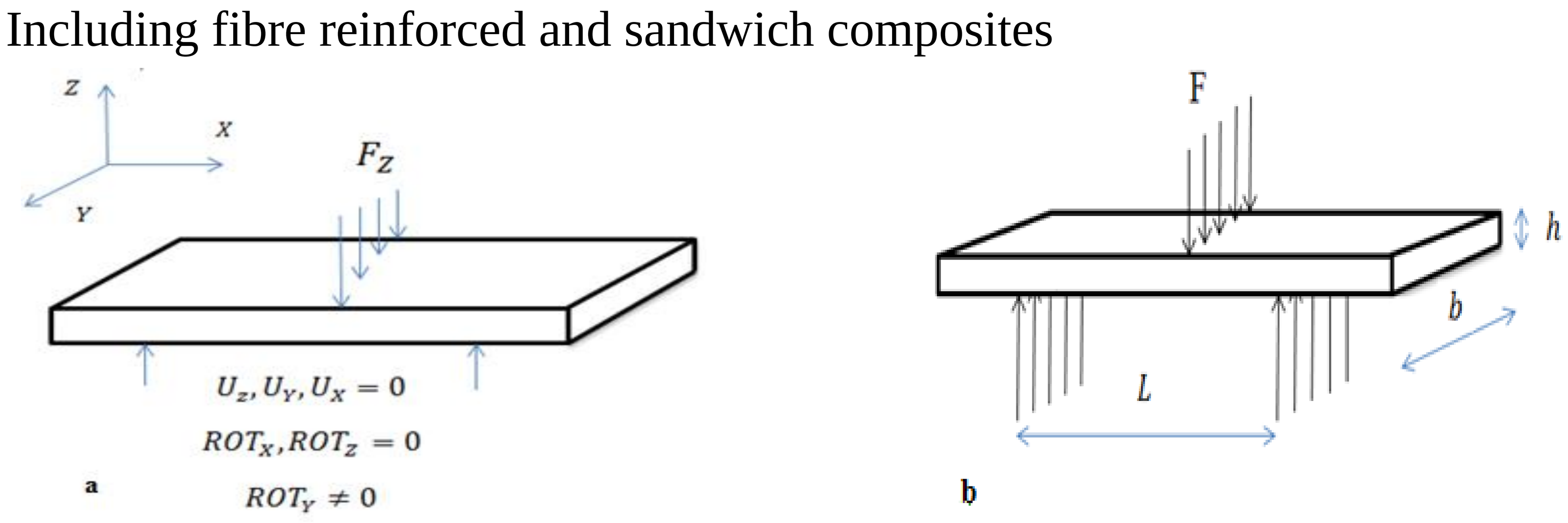
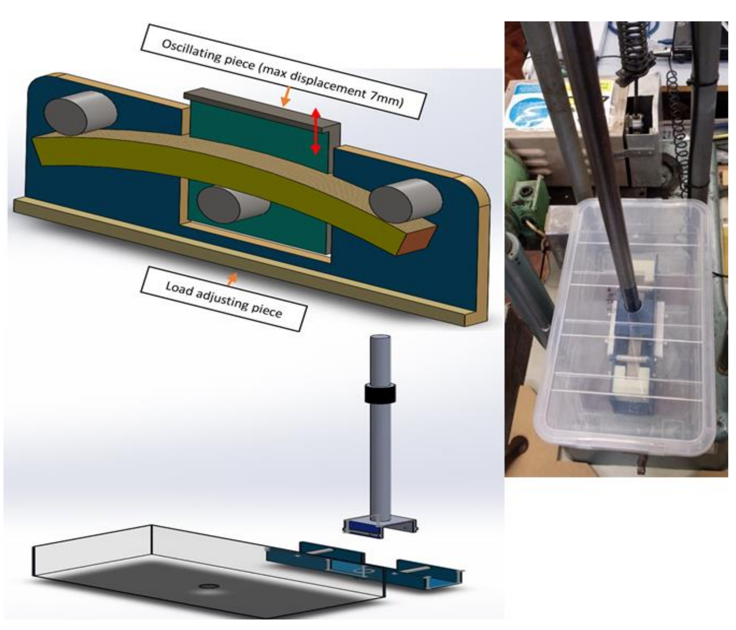


Fig.1 Test configuration for 3PB according to British standard BS EN ISO 14125 for static tests and BS EN ISO 13003 for cyclic test: (a) Load application and boundary conditions; (b) Schematic representation of 3 point bending test set up.



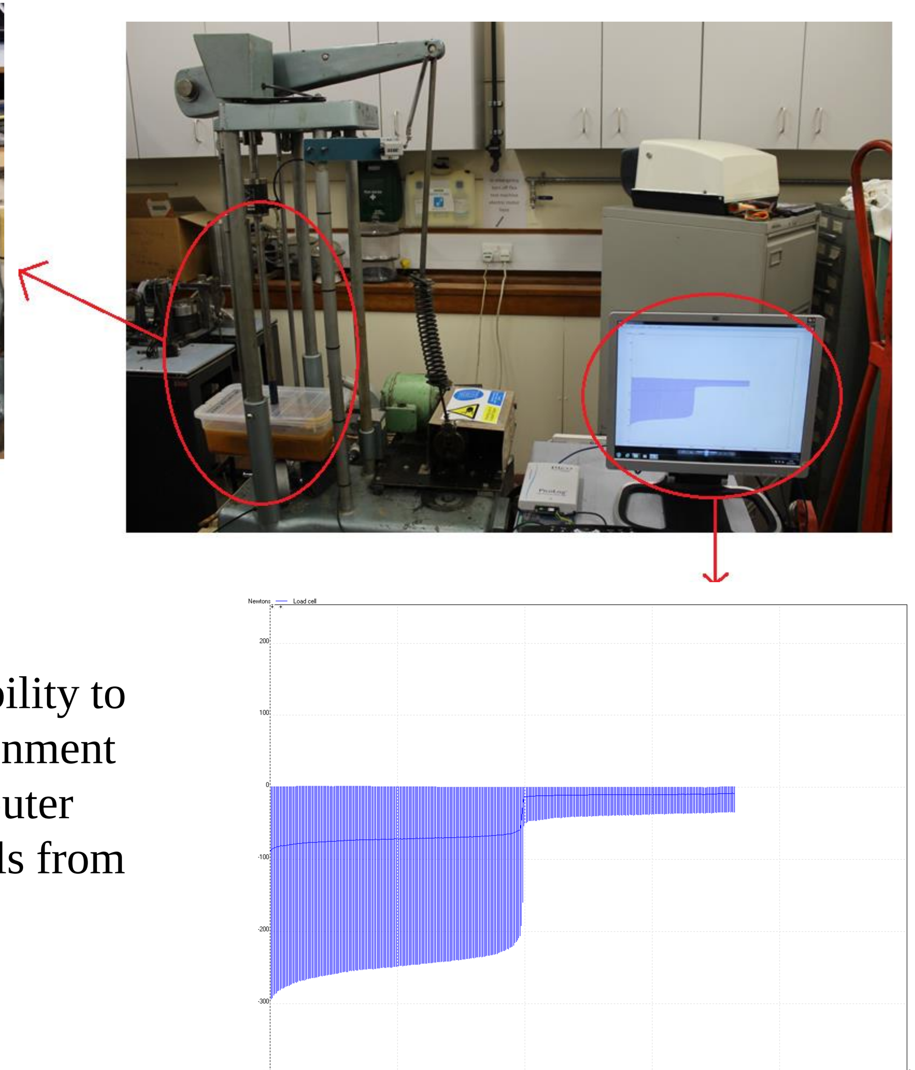


Fig. 2 Flexural fatigue rig with capability to conduct the test in a sea water environment

Fig.3 Data logger connected to computer records load-time variation via signals from Load cell

Results and discussion

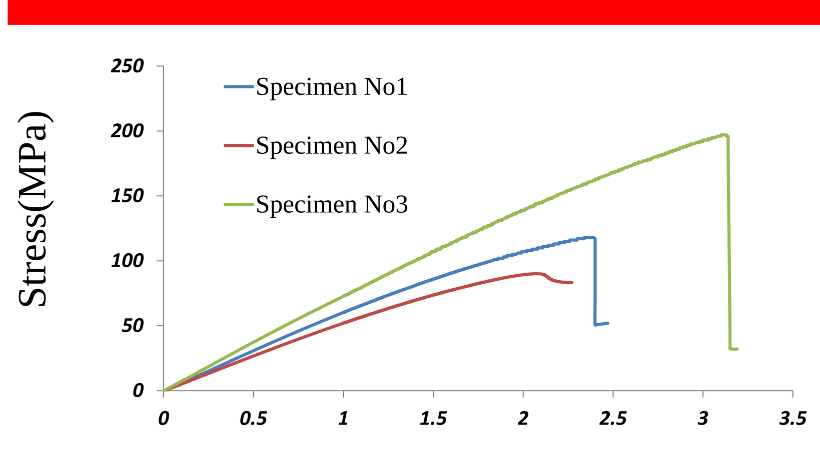


Fig.3 Stress-strain curves for sandwich specimens.

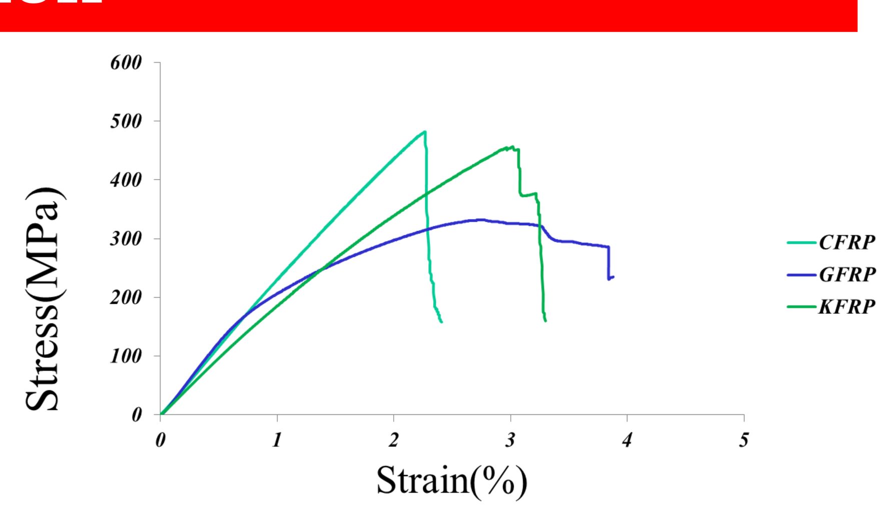
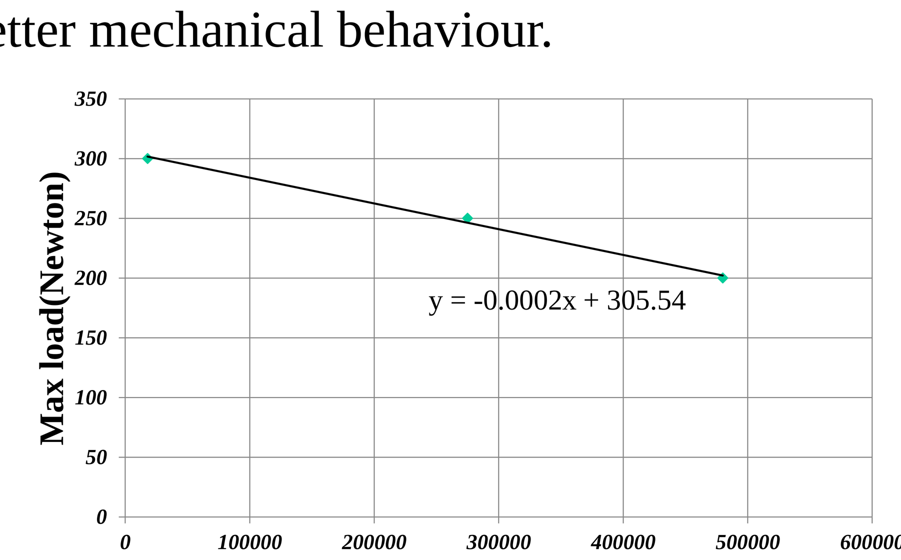


Fig.4 Stress-strain curves for fibre reinforced composites .

➢ Fibre reinforced composite materials: although Carbon fibre and Kevlar fibre epoxy resin show a higher strength, Glass fibre epoxy resin has a higher modulus which indicates a bout a flatter S-N curve and superior fatigue life

➢In Sandwich composite structures, decreasing number of layers and core mat thicknesses will result in better mechanical behaviour.

Fig.5 The most important output of flexural fatigue tests is S-N curve was obtained for sandwich composite structures , enabling engineers to predict the fatigue life, fatigue strength and endurance limit of fatigue



FEM analysis-3PB test simulation

➢Numerical simulation were conducted using ANSYS 15. final element software

➢Element Shell 181 suitable for composite structures

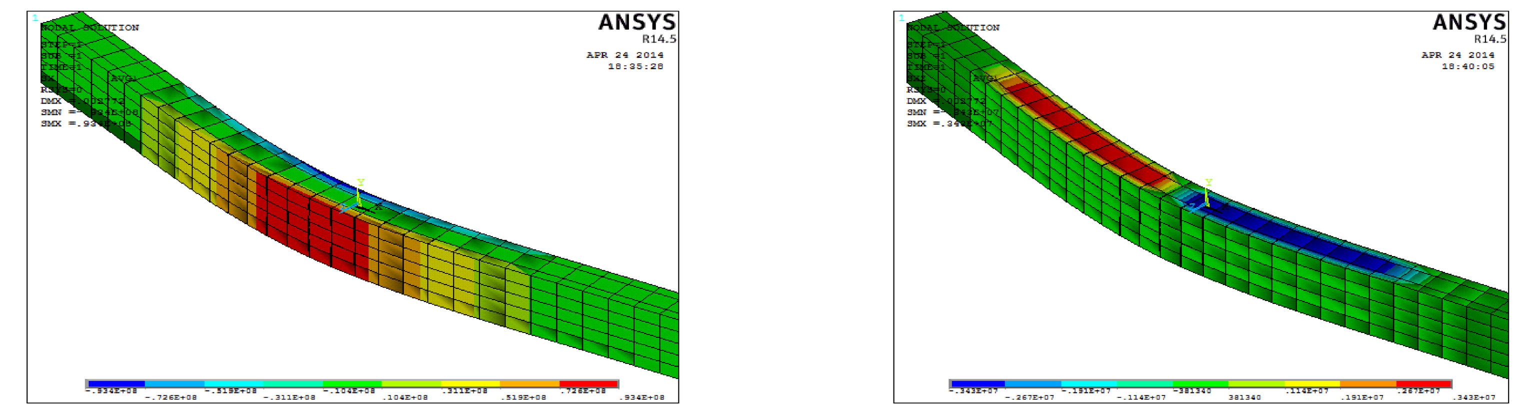


Fig.6 Face sheet bending and core mat shear stress contours for a typical sandwich structure

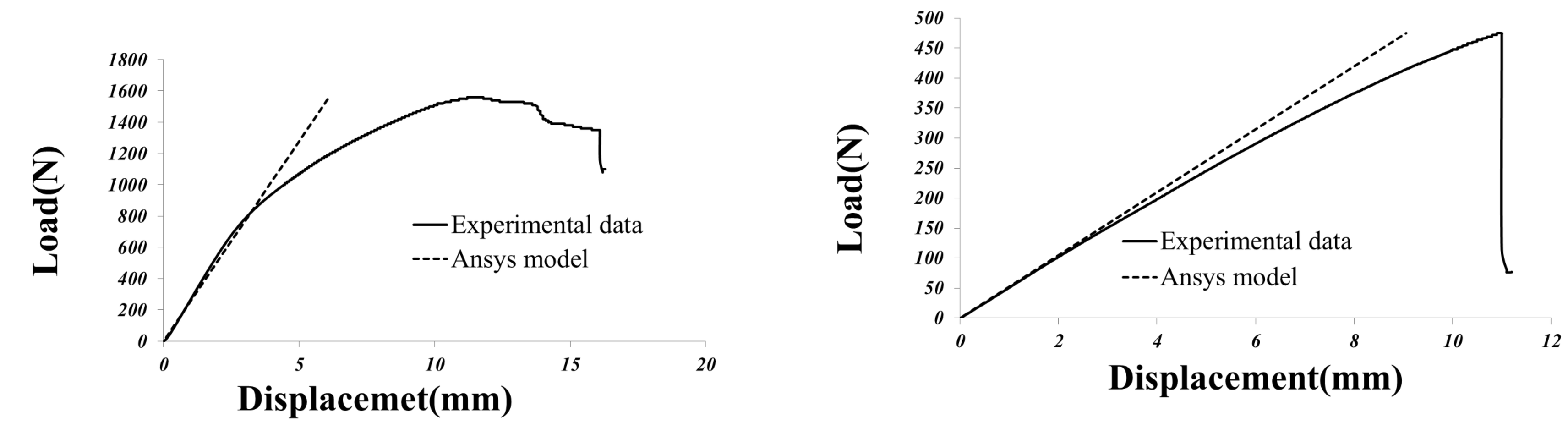


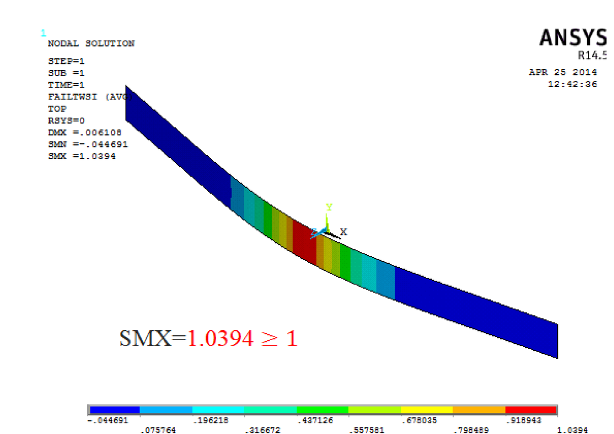
Fig.7 Numerical/experimental comparison for fiber reinforced and Sandwich composites

➢Comparison between 3PB experimental load/displacement results with those from the numerical analysis , evidencing a close agreement in low load regime between them

Failure criteria

➢According to Tsai-Wu quadratic interaction failure criterion failure of fiber reinforced epoxy resins under max load in load deflection curve is predicted

➢According to max stress failure criteria failure mechanism are fiber tension and fiber compression



CFX and Static Structural Analysing

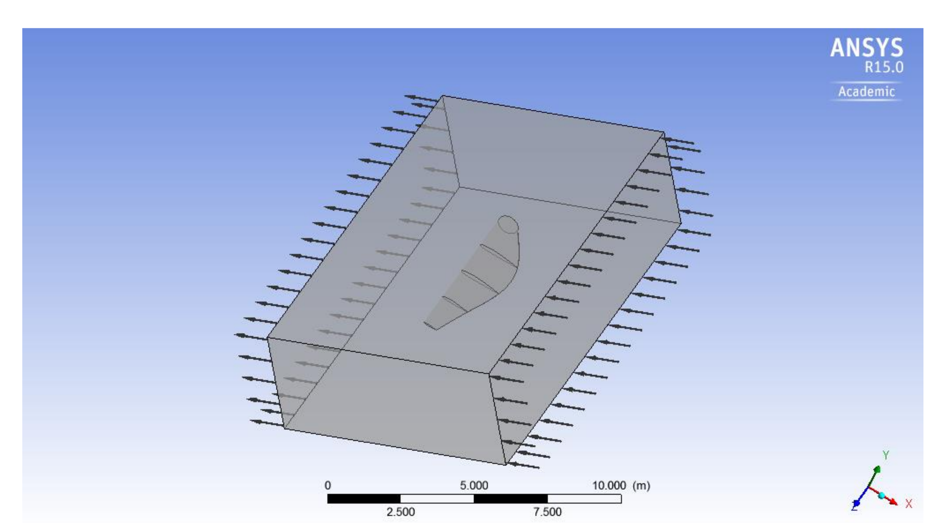


Fig.8 inlet: velocity 2.5m/s outlet: Relative pressure at the depth of 50m of about 0.6Mp

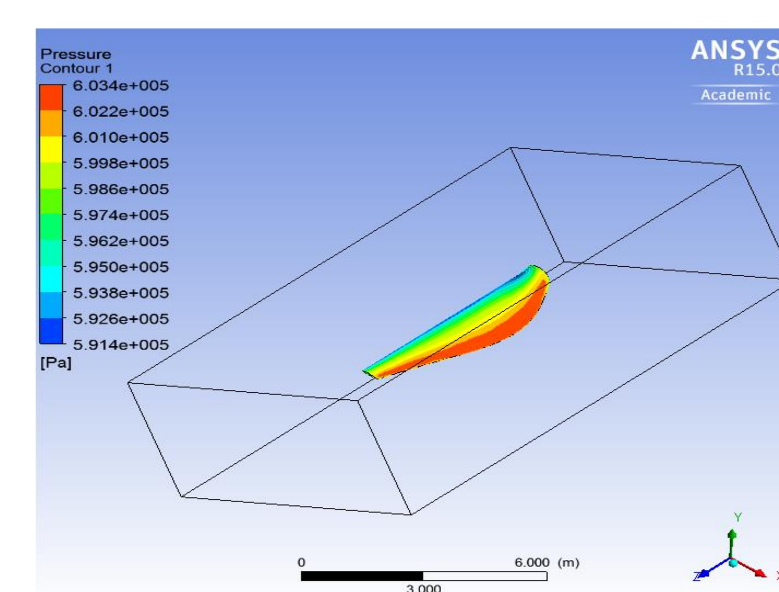
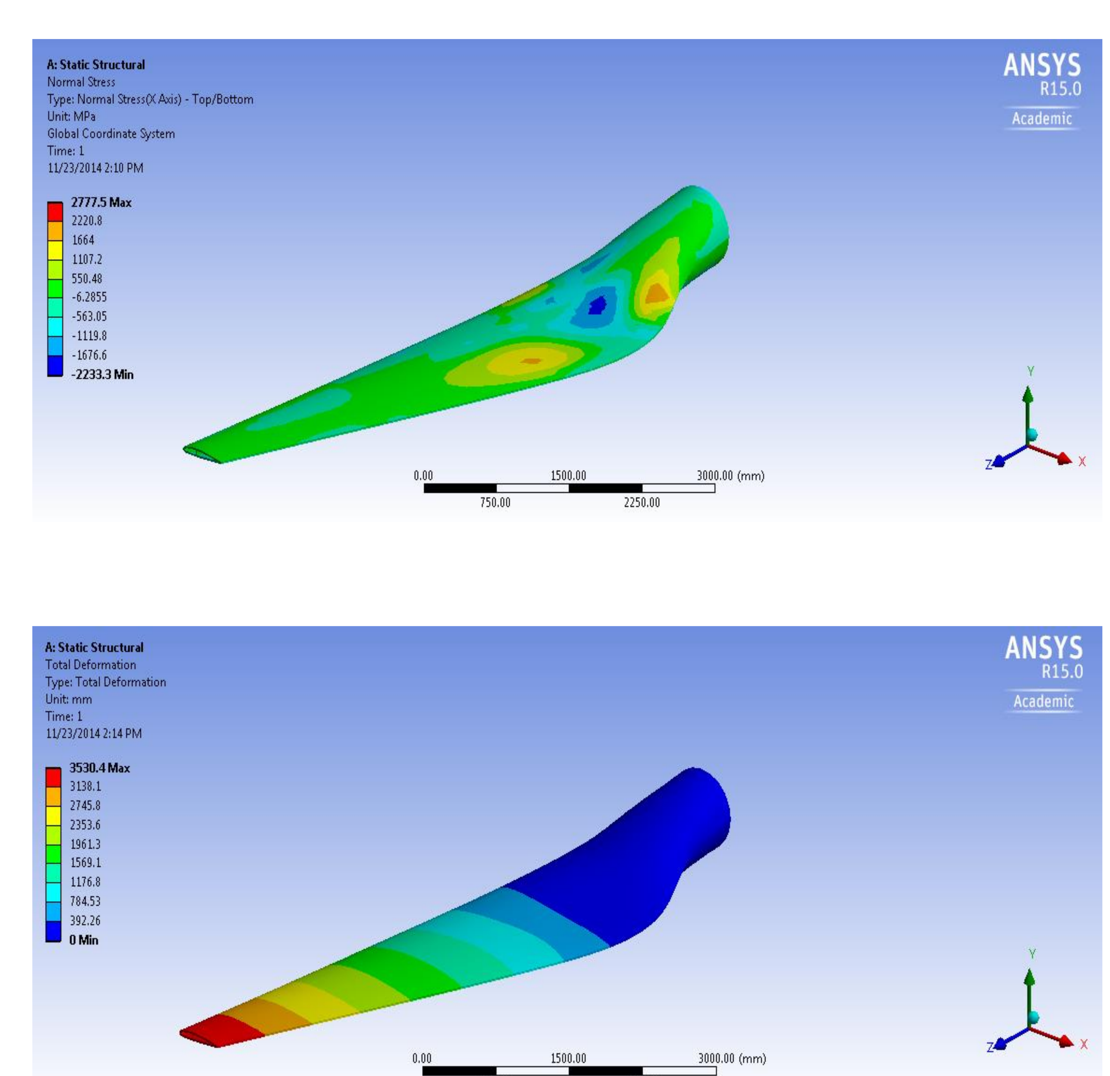


Fig.9 pressure distribution at the surface of tidal turbine blade

Fig.10 By importing pressure distribution from CFX modelling and information about mechanical behavior, S-N curve from experimental section into Static Structural Analysing: Distribution of normal stresses and deflection contour on the surfaces and spar of tidal turbine blades which can be observed which can contribute engineers for fatigue failure of tidal turbine blades



Future work

➢ Distinguishing and locating failure mechanisms during fatigue tests by:

- SEM or optical microscopic technique
- Nanoindentation technique

➢ Evaluation of Fatigue behavior on tidal turbine blades using ANSYS n Code design life software

➢ Utilizing ACP Software in ANSYS for analyzing tidal turbine blades made of composite materials