Modelling of Wind Turbine Main-Bearings

James Stirling, Dr Edward Hart, Dr Abbas Kazemi Amiri, Dr Alasdair McDonald

Wind & Marine Energy Systems CDT, Rm 3.36, Royal College Building
University of Strathclyde, 204 George Street, Glasgow, G1 1XW

j.stirling@strath.ac.uk

Project Overview

Wind turbine main-bearings are failing with much greater frequency than expected. The main reason for this is thought to be the gap which exists between main-bearing design procedures, which focus on fatigue loading and assume relatively constant load conditions, and the real loading experienced by main-bearings in operational wind turbines which are highly stochastic in nature. The extension of existing theory to account for realistic loading conditions experienced by wind turbine main-bearings has huge scope to lower the levelised cost of energy since it would allow for improved lifetime prediction, the development of new and more sophisticated testing procedures for bearing certification and would certainly contribute to improvements in design methodologies. This PhD seeks to develop and compare varying complexity models of wind turbine main-bearing designs before applying them in order to study, in detail, one of the following outcomes:

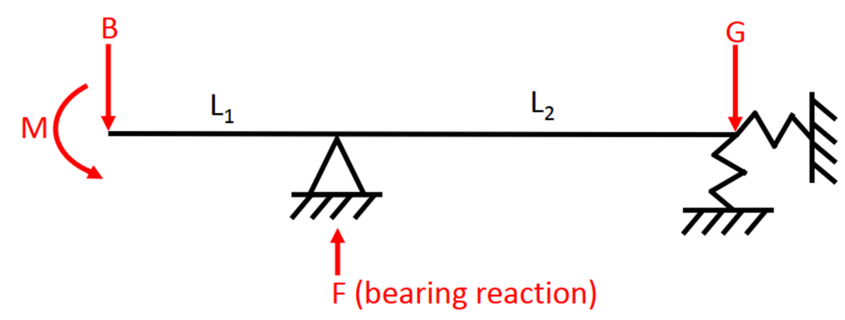
Development of main-bearing dynamic damage metrics and remaining lifetime prediction approaches

Development of new procedures for main-bearing testing and certification which account for realistic dynamic loads (including accelerated testing)

Main bearing design analysis based on realistic loading, including comparisons of existing designs and the development of new solutions to reduce harmful loads (e.g. the potential for additional mechanical damping).

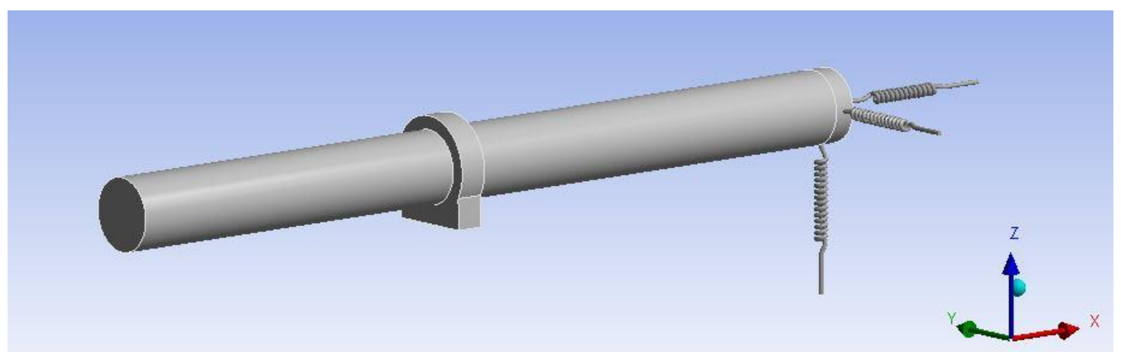
Simple 2D Beam Model

A simple two dimensional beam support model of a commercial drive train was utilised to analyse main-bearing loading across many wind field conditions with the goal of determining global trends. The model is limited in that the bearing is modelled as a single point fixed support, however, it is fast and computationally efficient. This opens up the possibility for large numbers of load profiles to be run quickly, resulting in statistically significant outputs.



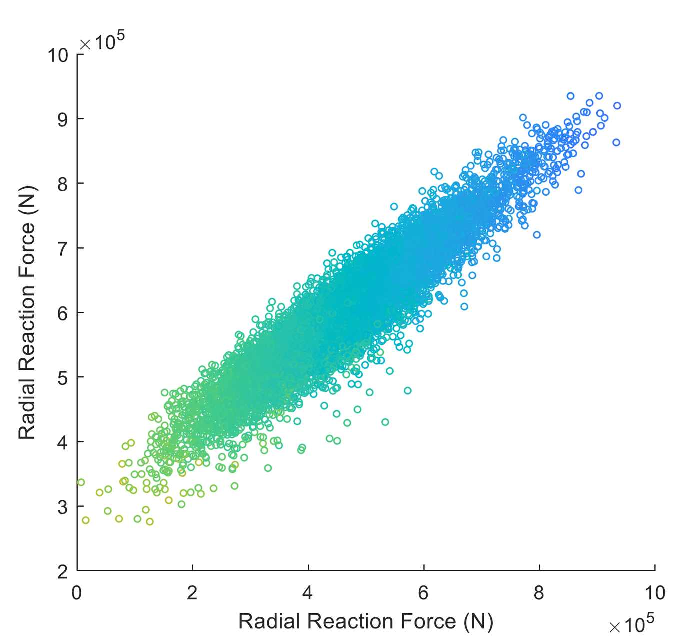
3D ANSYS Model

A 3D FEA model of the drivetrain set-up was created to help understand the limitations and capabilities of the simple beam model. The 3D model is still a simple representation of the single main-bearing drivetrain set-up and the reaction forces were measured from the base of the bearing housing to emulate the 2D model and serve as a proxy to the loading experienced by the bearing.

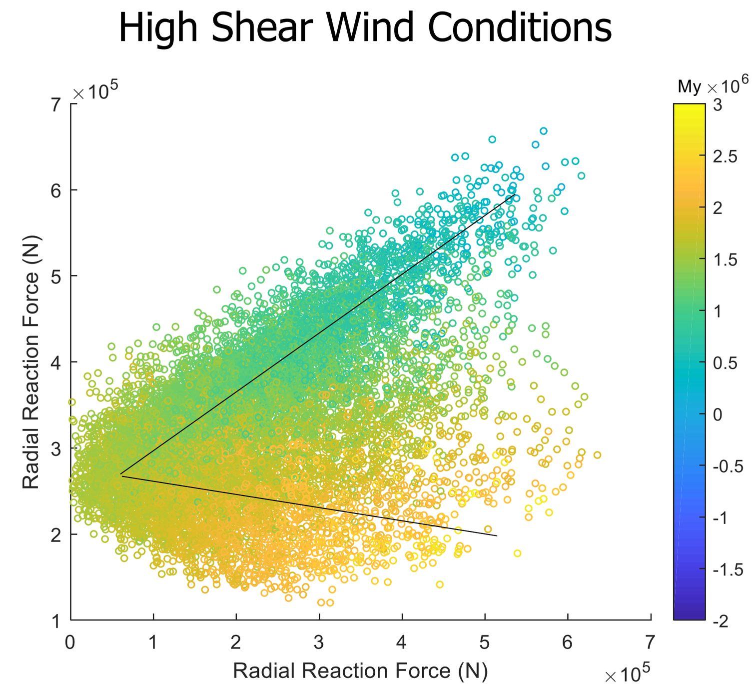


Correlations Between the 2 Models

Low Shear Wind Conditions

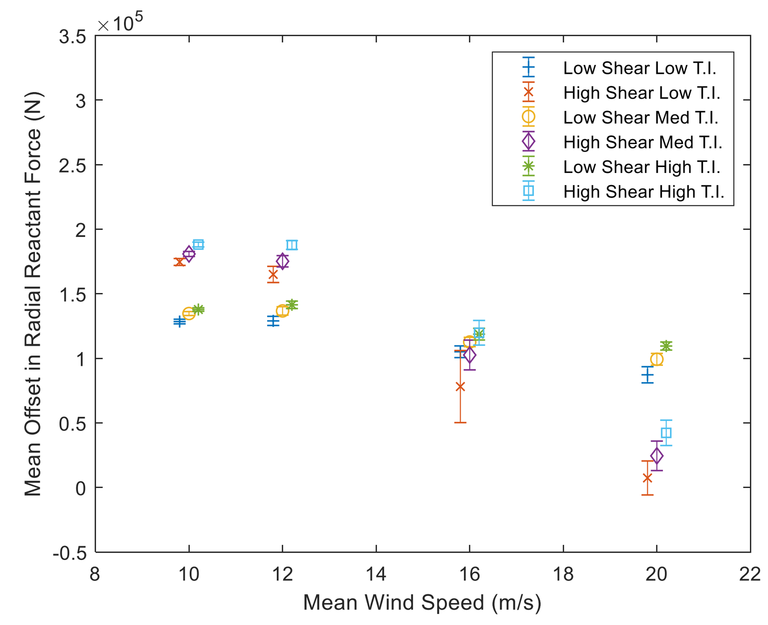


High Shear Wind Conditions

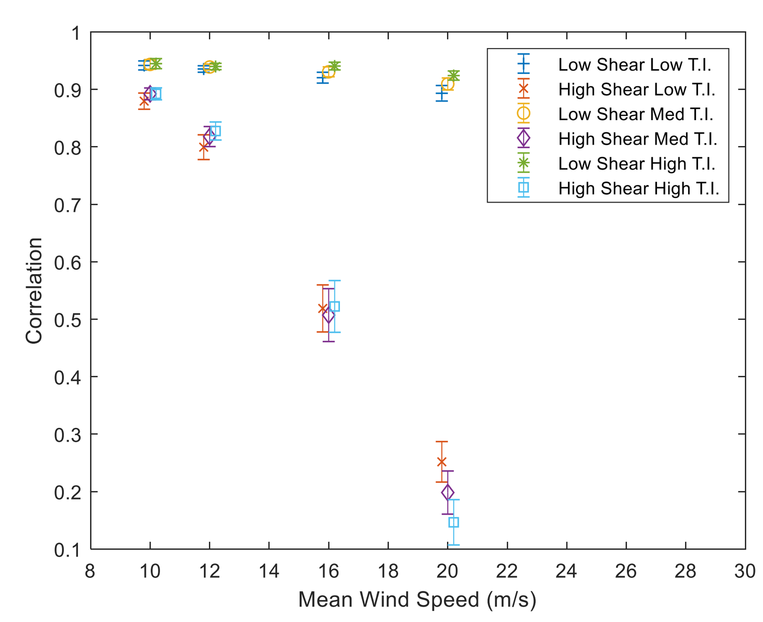


Correlations and Mean Offsets Between the Models for All Wind Profiles

Mean Offset between the 2 Models

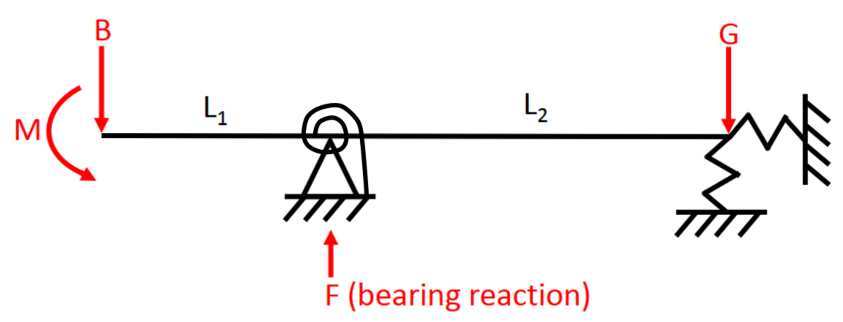


Correlation Between the 2 Models



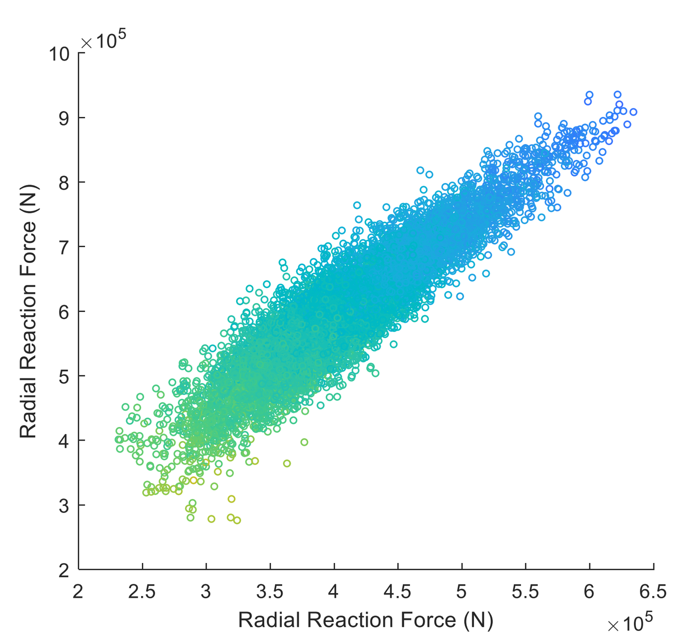
2D Beam Model With Torsional Spring

The correlation between the radial reaction force results from the two models were investigated for each load file and plotted in the figures above. The correlation proved to be good for low wind shear conditions and poor with high shear conditions, decreasing as mean wind speed increased. Two correlation mechanisms appeared between the models under high shear conditions, thought to arise from the flipping of the principal moment directions on the hub. A torsional spring was then added to the simple beam model to try and combat this problem.

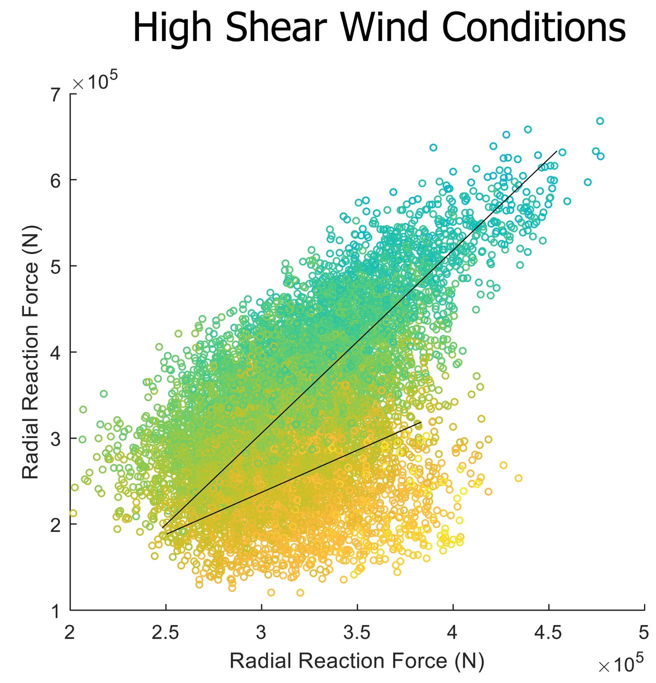


Correlations Between the 2D Beam With Torsional Spring and 3D Models

Low Shear Wind Conditions



High Shear Wind Conditions



EPSRC Engineering and Physical Sciences Research Council
wood.
SCOTTISHPOWER RENEWABLES
SNC·LAVALIN
ATKINS Member of the SNC-Lavalin Group
FRAZER-NASH CONSULTANCY
futureWind & Marine 2019