Further investigation of the relationship between main-bearing loads and wind field characteristics

A Turnbull[1], E Hart[1], D McMillan[1], J Feuchtwang[1], E Golysheva[2] and R Elliott[2]

[1]University of Strathclyde, Glasgow, UK
[2]Romax InSight, Nottingham, UK

Engineering and Physical Sciences Research Council

Motivation

- Main-bearings seldom reach design life of roughly 20 years.
- Some failing after as little as 6 years [1].
- Reasons for this are still not fully understood.
- Cost associated with the repair is expensive.
- As we move further offshore, these effects are amplified due to cost of support vessels, weather and access restrictions.

Research aims

1. Create a simple model which focuses on realistic input loads from which cause and effect can be easily separated.

2. Understand loading across wind turbine operating envelope and link this to wind field conditions.

3. Provide evidence to support claims that axial to radial load ratio is a key factor in main bearing failure.

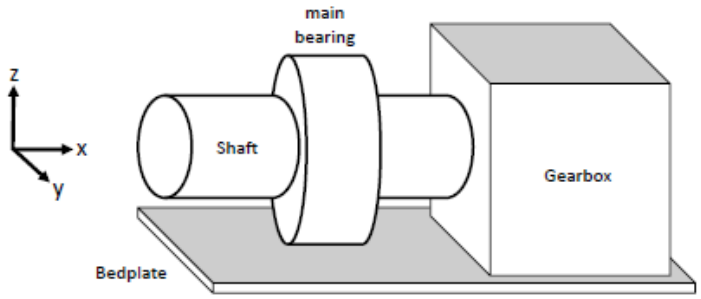
Aeroelastic model

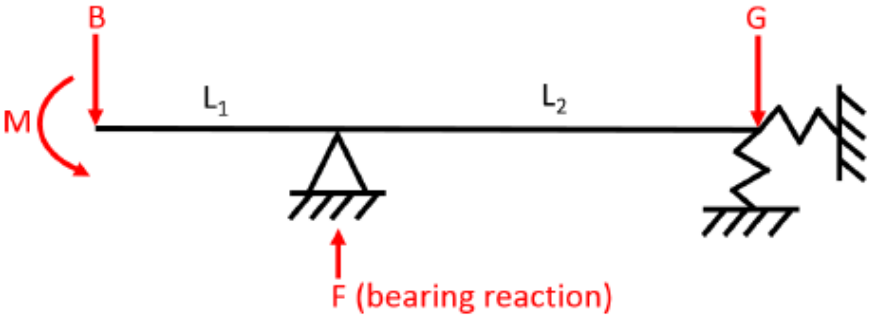
- GH Bladed software used for aeroelastic wind turbine simulations.
- Wind field characteristics
  - 4 wind speeds (10, 12, 16, 20m/s)
  - 2 shear profiles (shear exponent 0.2, 0.6)
  - 3 turbulence intensities (high, med, low as described in IEC standards [2])
- 144 different wind fields to define operating envelope.
- Hub forces and bending moments extracted in all three degrees of freedom.

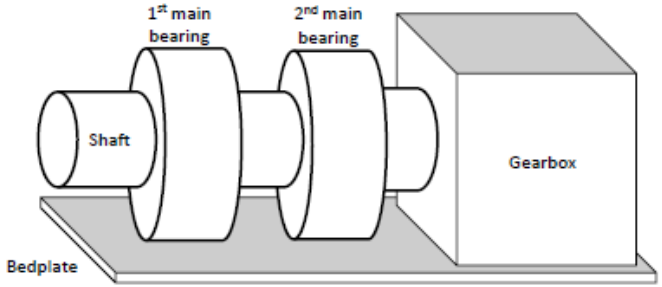
Drivetrain model

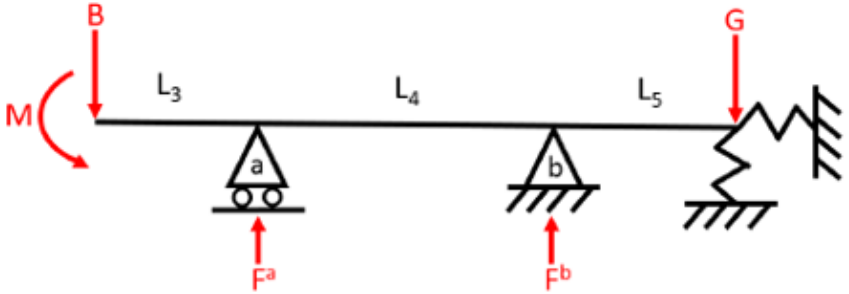
- Drivetrain models generated for both double and single main bearing configuration.
- Separate model for radial and axial loads.
- Lengths and spring stiffness's determined by ROMAX Insight FEA modelling software for commercially available wind turbine of rated power around 2MW.
- Bearing type dependent on the configuration.

Drivetrain model

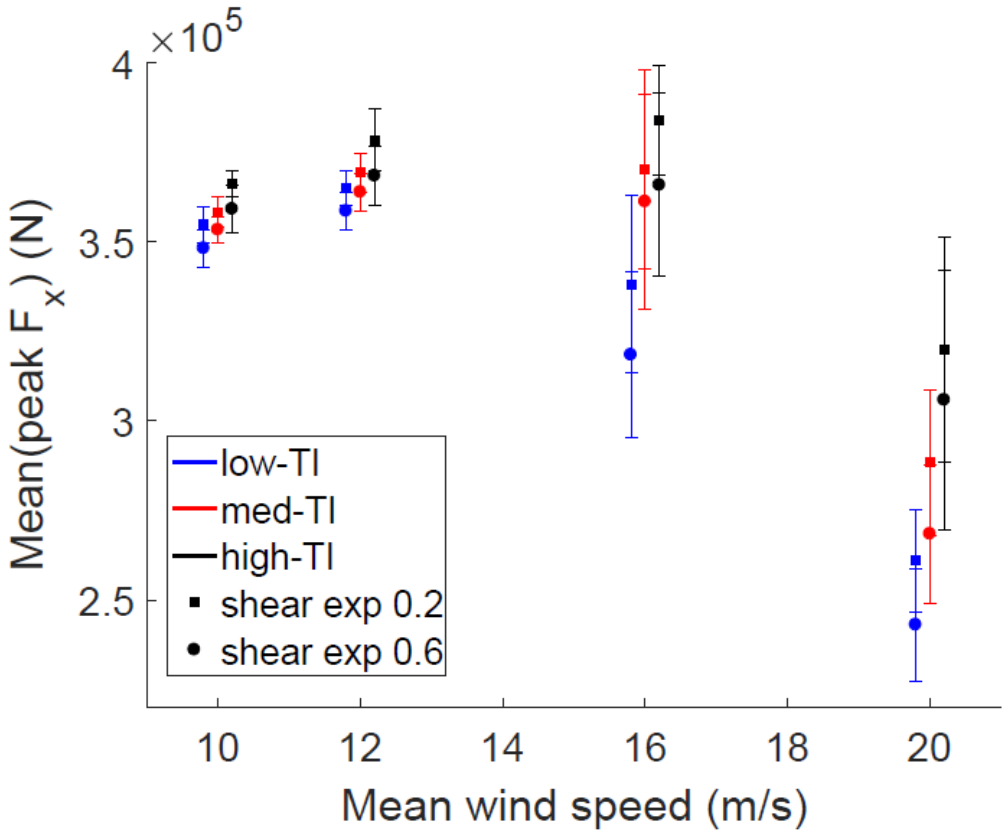




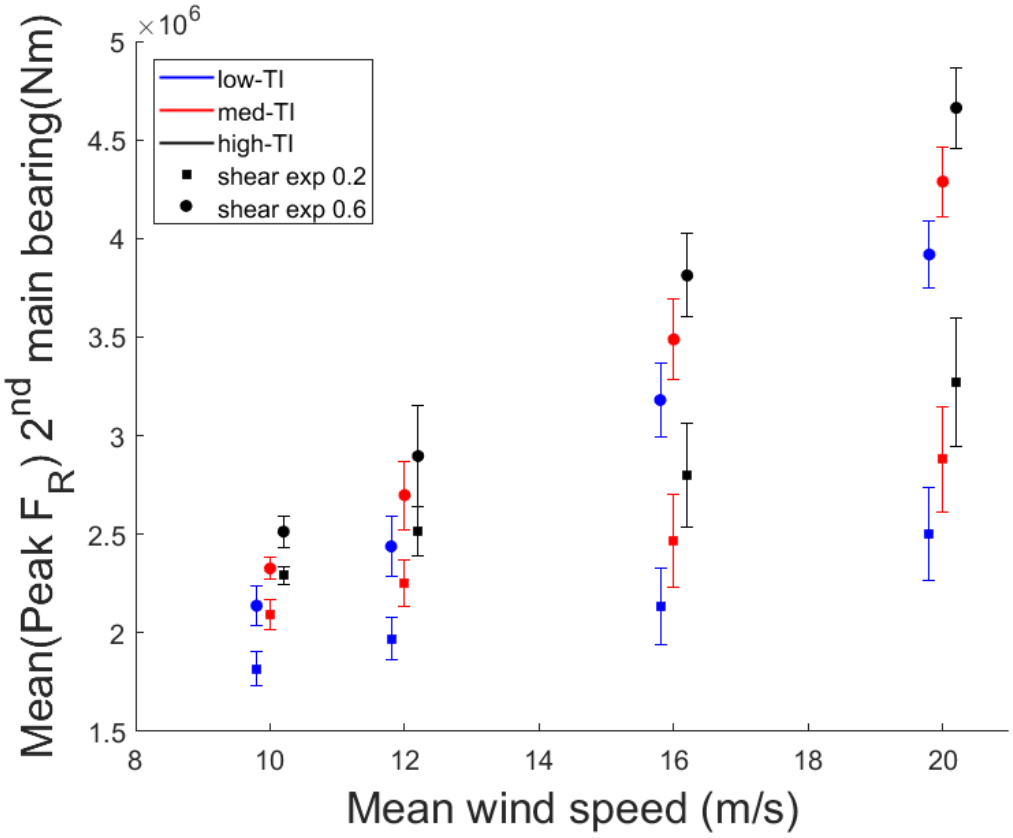




Results – Peak axial loads

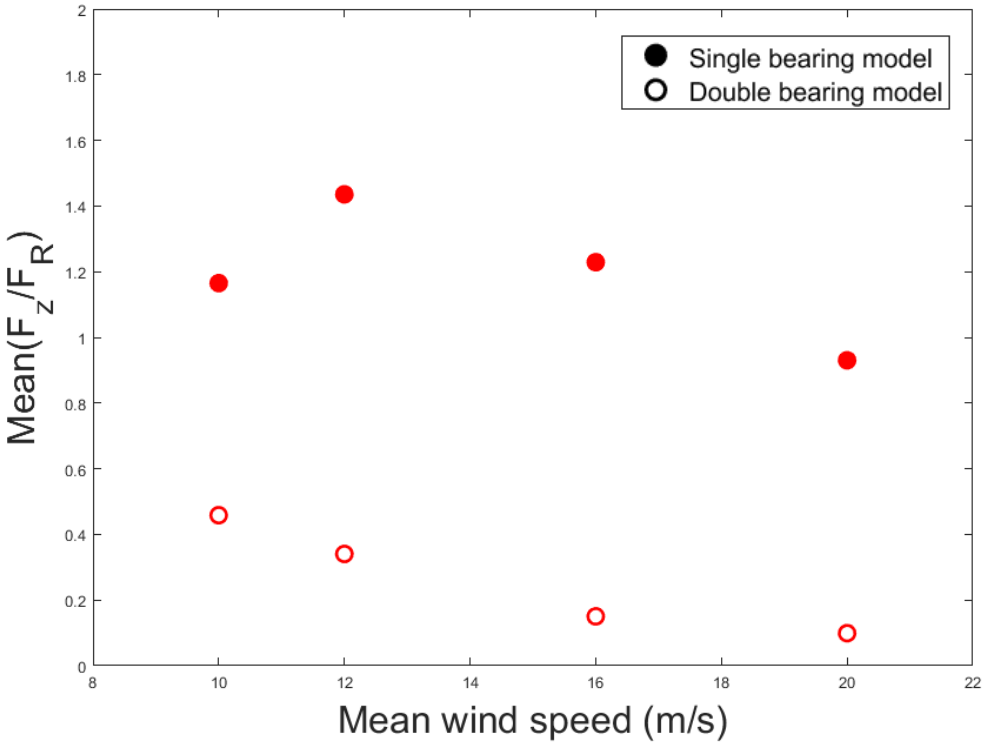


Results – Peak radial loads



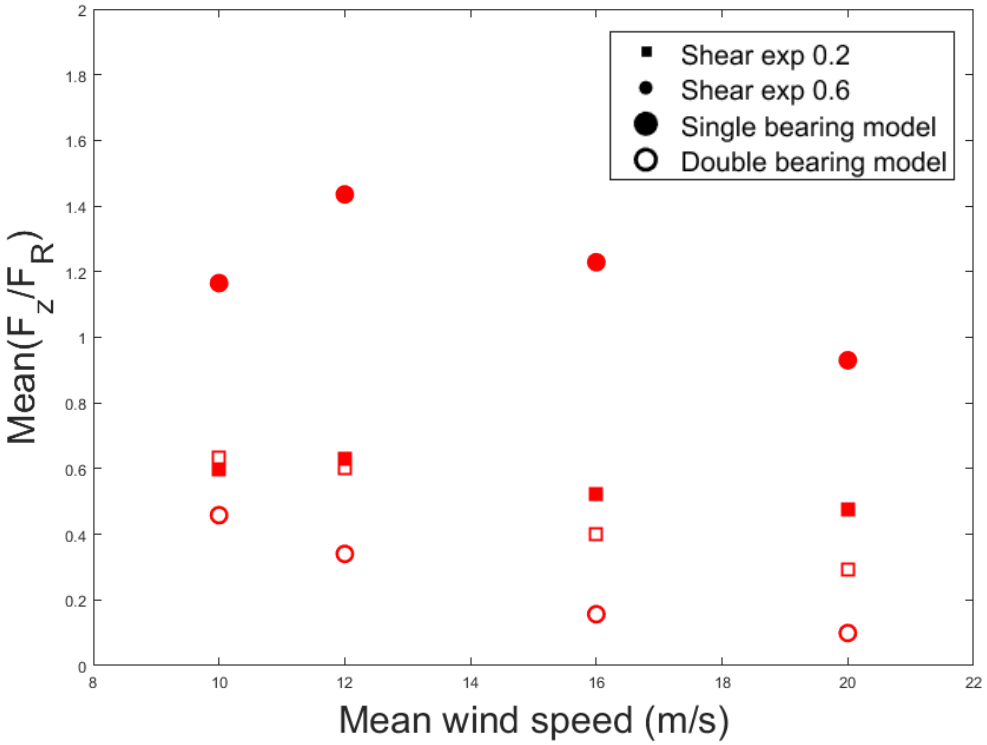
Results – Load ratio

Medium turbulence intensity and high shear



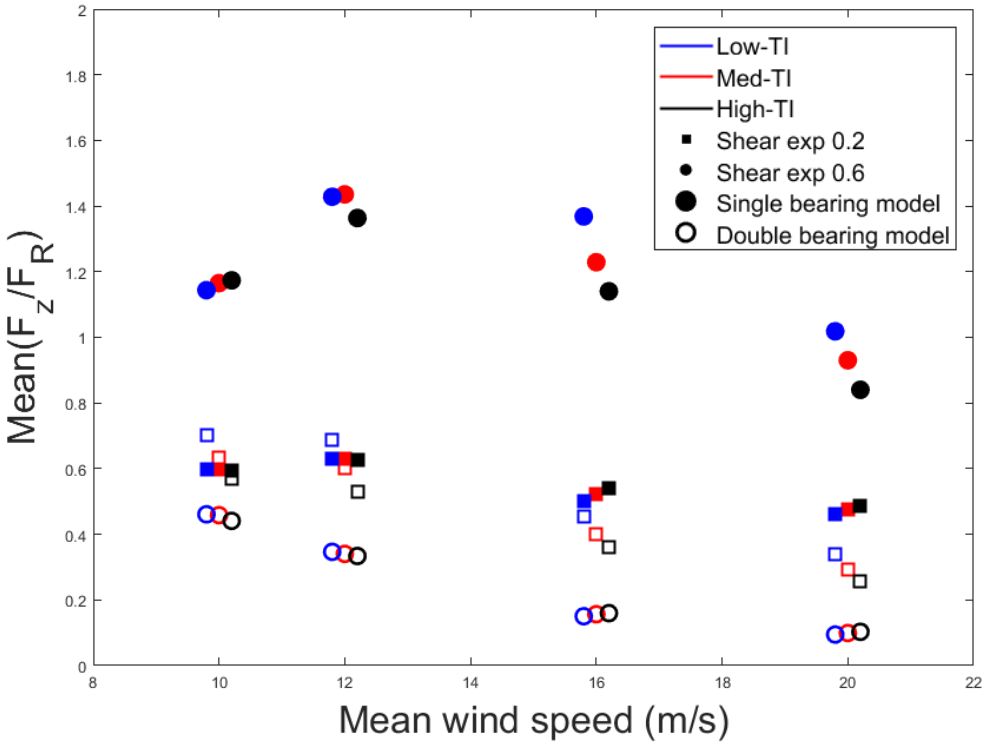
Results – Load ratio

Effects of shear profile



Results – Load ratio

Effects of turbulence intensity



Conclusions

- Strong link between wind conditions and main bearing loads for both configuration – wind shear highest sensitivity factor.
- In general it can be observed that the double bearing configuration experiences a significant decrease in load ratio.
- Highest load ratio occurs in the single main bearing configuration in high shear and low turbulent conditions.
- With single main bearing configuration observed to fail more often, evidence suggests there could be link with load ratio.

Potential impact of research

- Develop ways in which to bring the relationship into design stage when calculating component life, steering away from traditional methods of steady cyclic loading.

- Use relationship as a factor to support decision making of wind turbine type/configuration at particular site.

Thank you for your attention, any questions?