



A Comparative Study of Finite Element Methodologies for Torsional Vibration Response Calculations of Bladed Rotors

R Scheepers

Supervisor: Prof. PS Heyns

19 February 2014



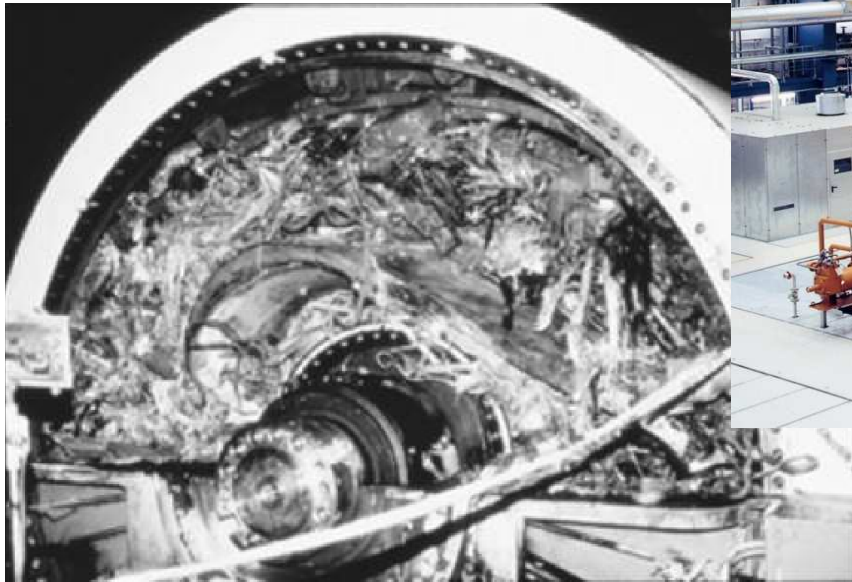
UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Overview

- Background
- Research contribution
- Experimental testing
- Modelling methodologies
- Measured and calculated results
- Conclusions

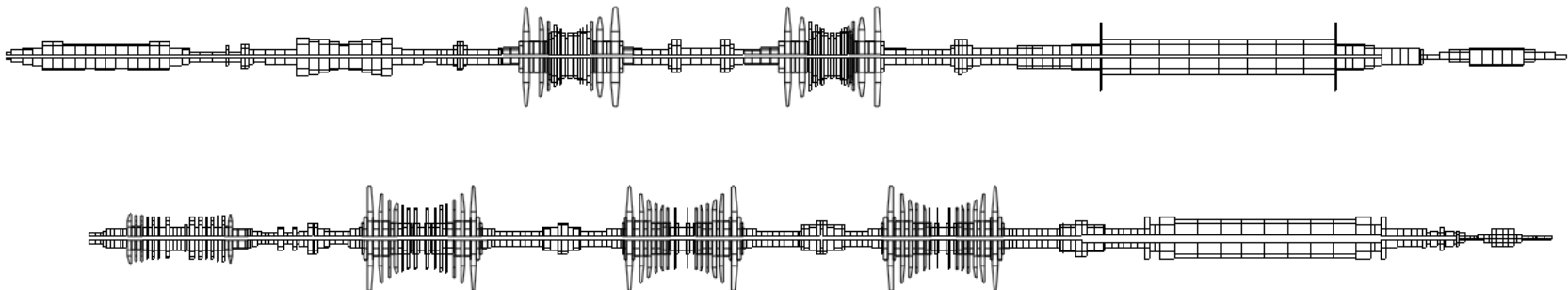
Background

- *Torsional excitation of turbo-generator trains*
- Short circuits
- Line switching
- Out of phase
- Resonance



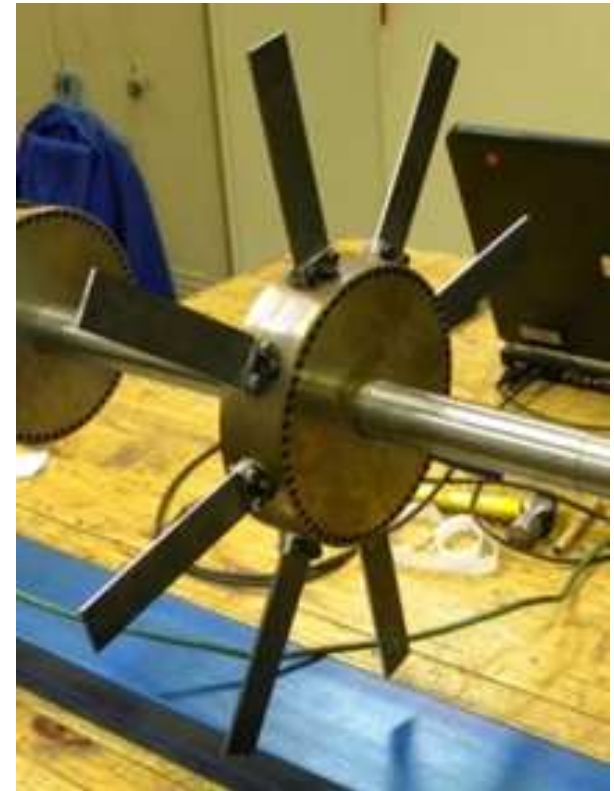
Background

- *Conventional modelling*
 - 1D lumped mass/distributed parameter FE models
 - LP blade participation – rigid blades
 - Sudden diameter change
 - Blade-to-disk rigidity
-
- Improved accuracy required
 - Move towards full 3D, 3DCS



Research Contribution

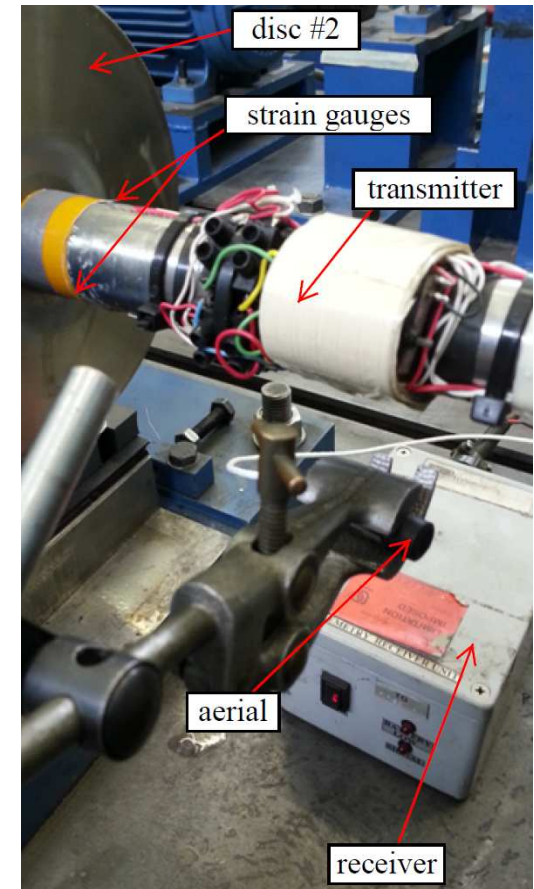
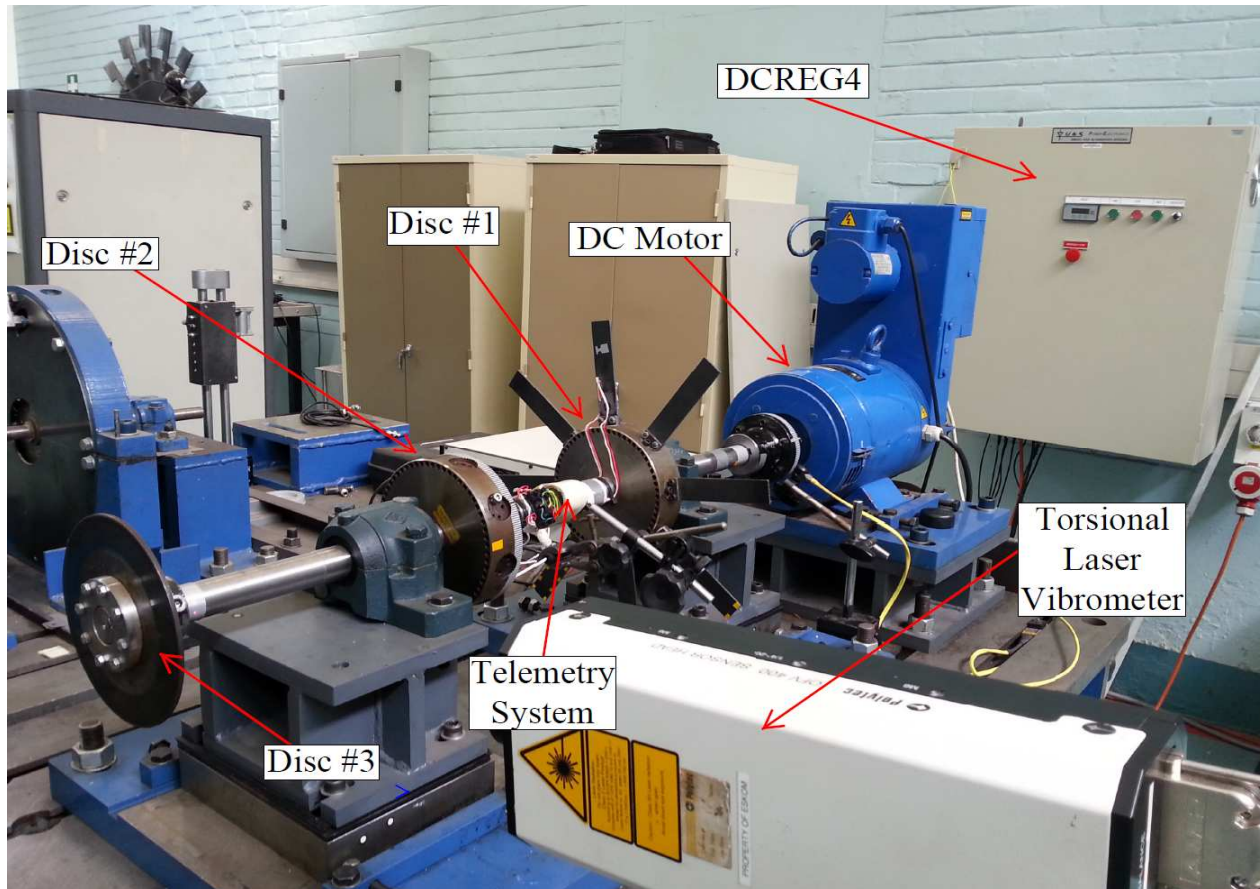
- Effect of blade stagger angle
 - Level of blade participation
 - Response frequencies
 - Damping
- Direct comparison of different FE methodologies
 - Solution time
 - Accuracy



90° stagger angle

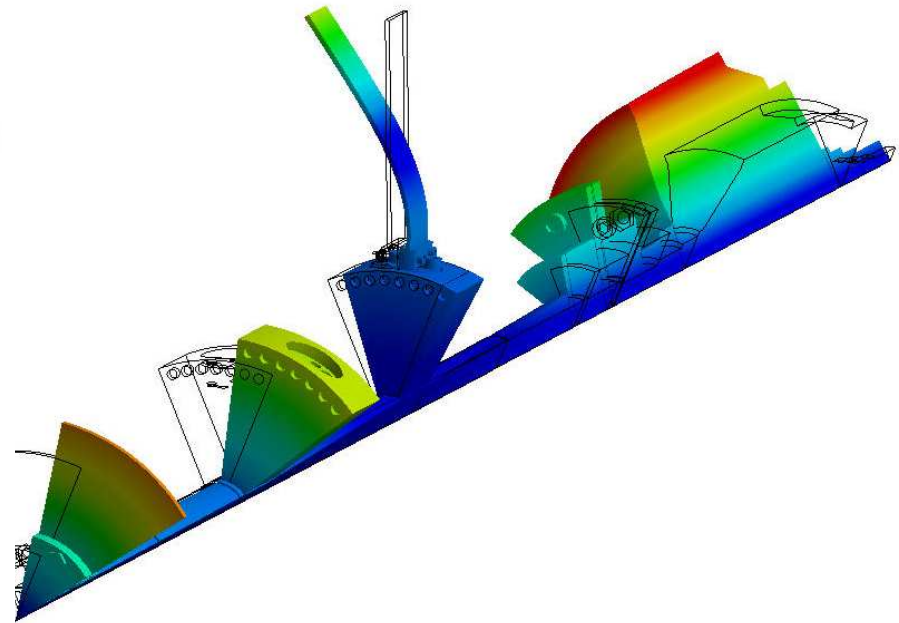
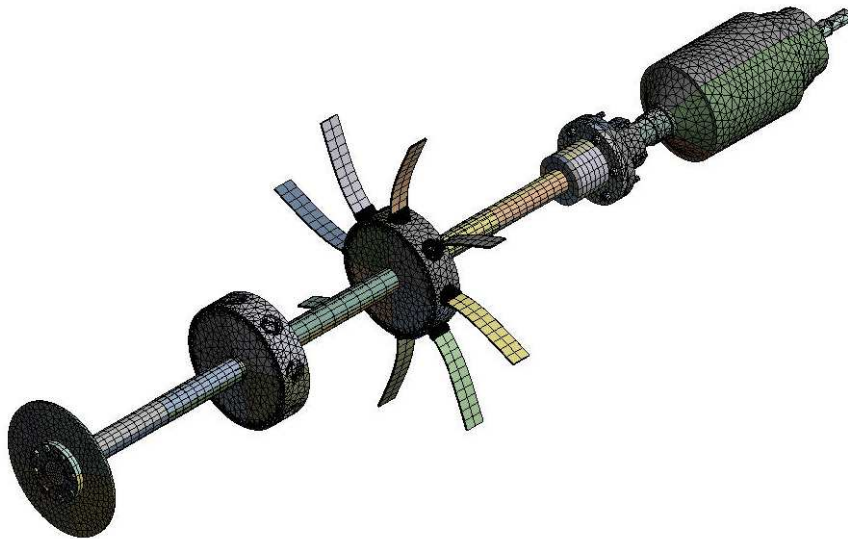
Experimental testing

- Small scale test rotor



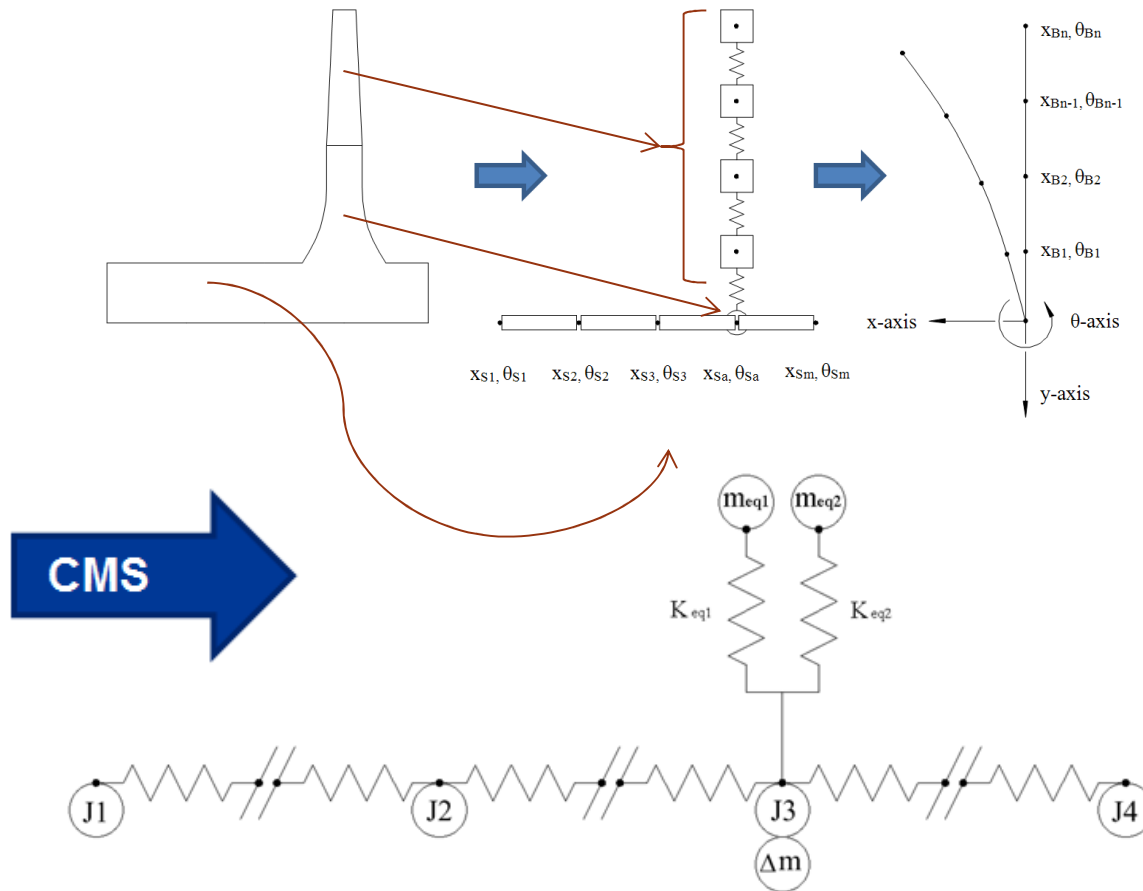
Modelling Methodologies

- Full 3D FEA
- 3D Cyclic symmetric
- 1D lumped mass



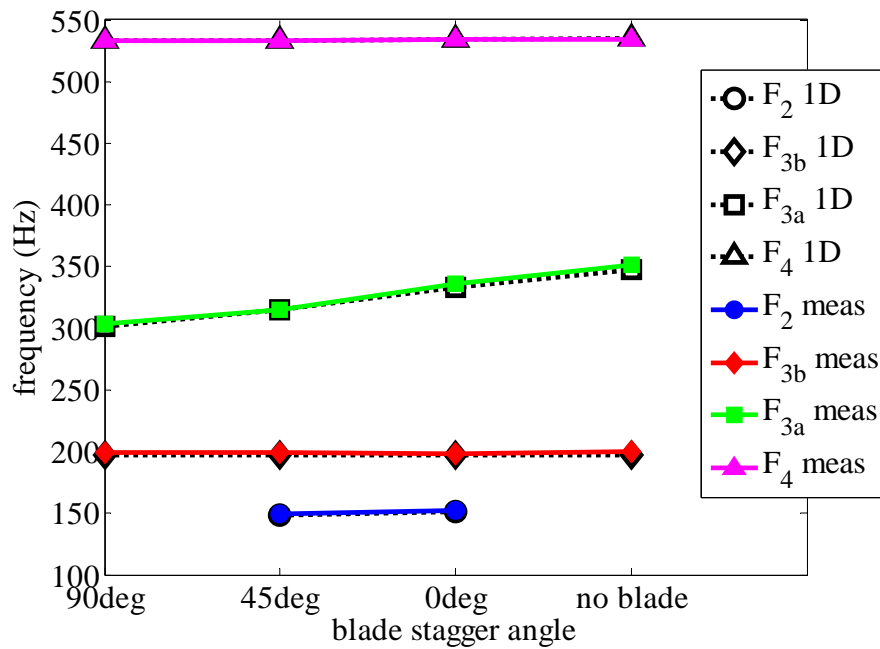
Modelling Methodologies

- 1D lumped mass – blade coupling

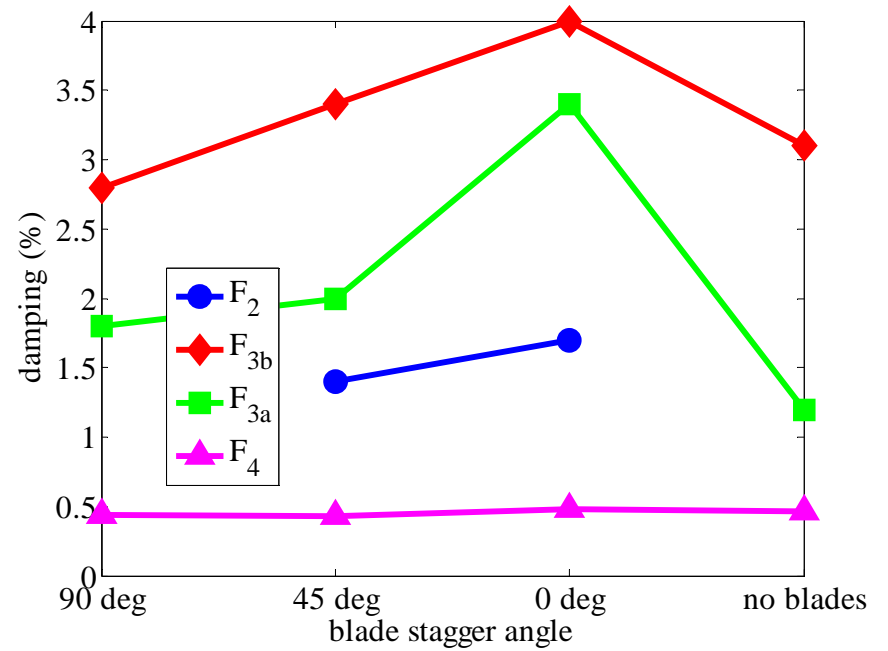


Results

Effect of blade stagger angle



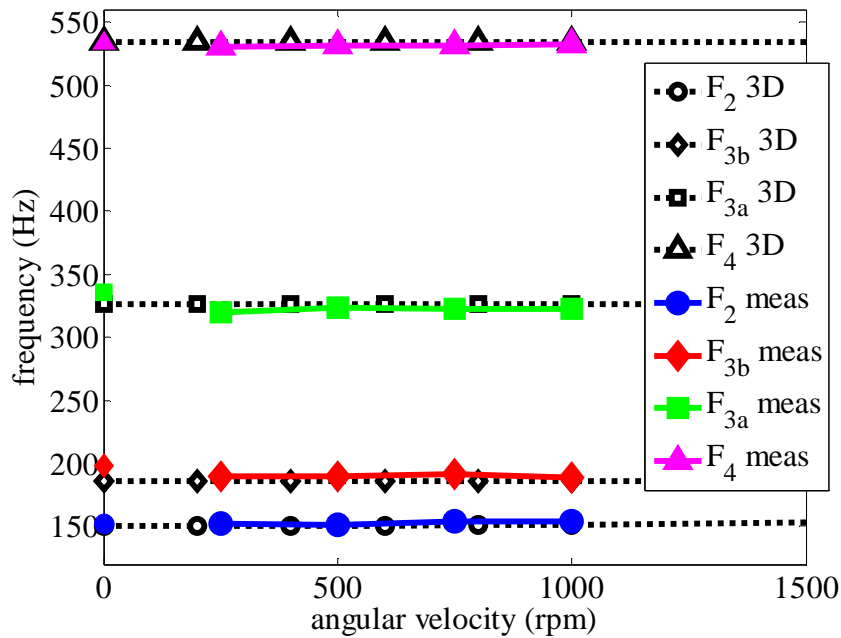
0 rpm



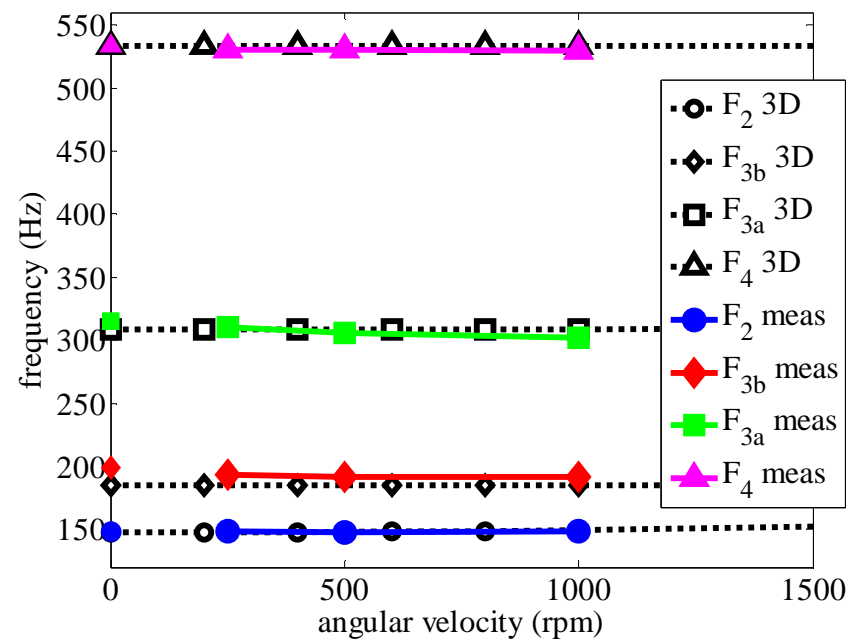
0 rpm

Results

Effect of centrifugal force



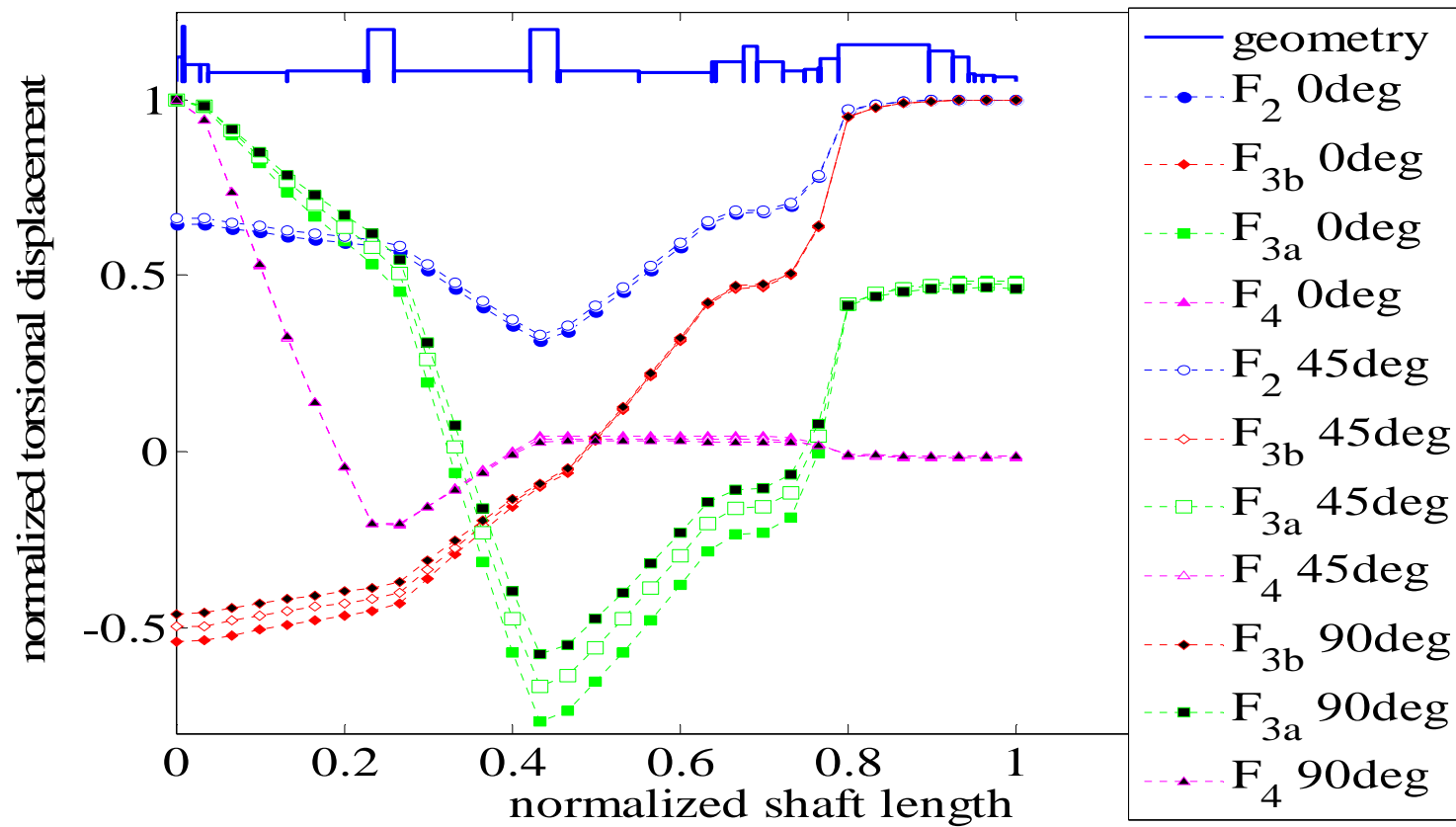
0° blade stagger angle



45° blade stagger angle

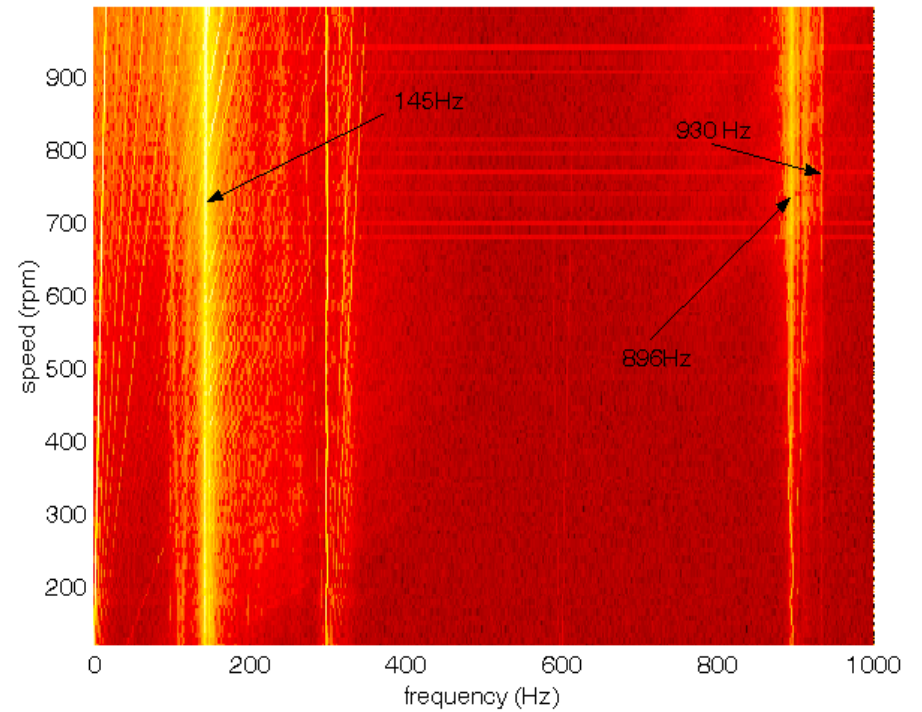
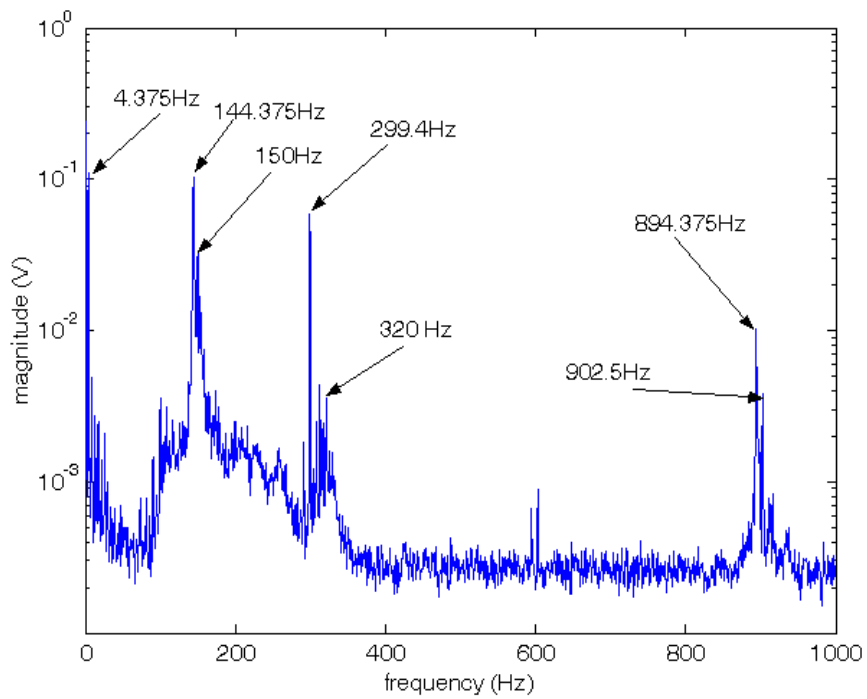
Results

- Effect of stagger angle on mode shapes



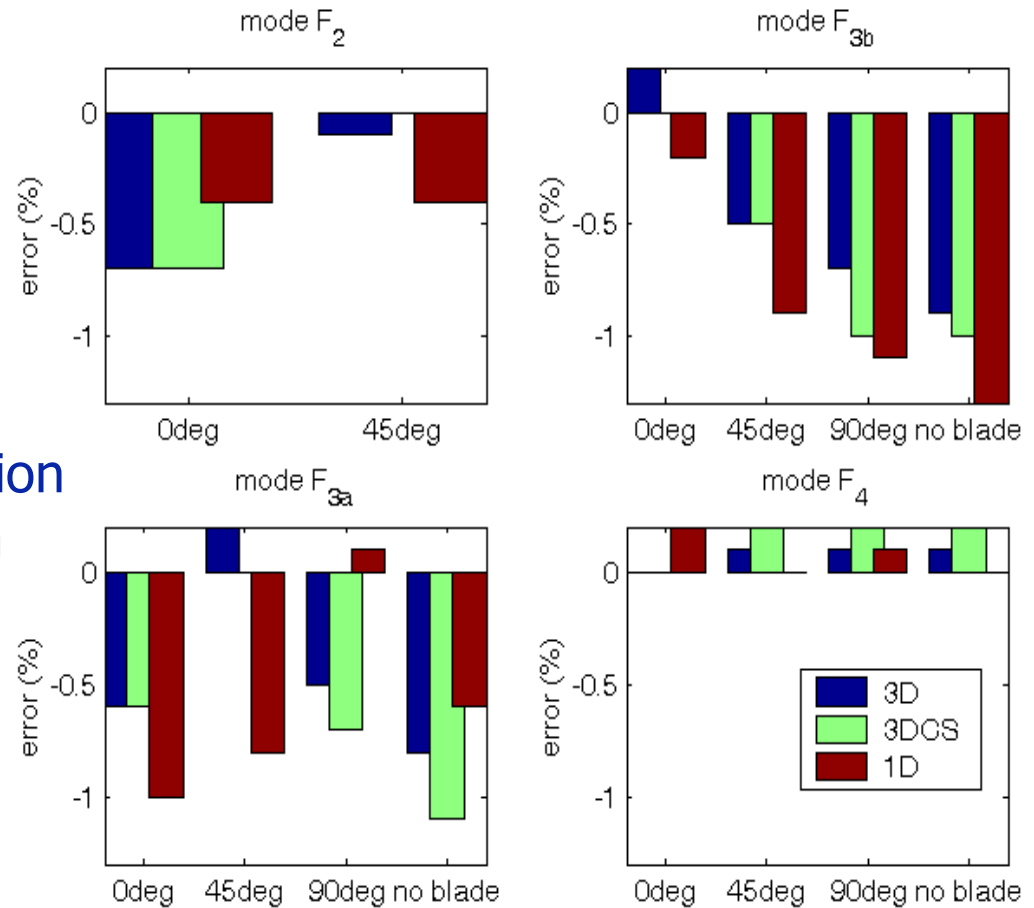
Results

- Blade response



Results

- Accuracy
- Solution times
 - 3DCS – 80% reduction
 - 1D – 99% reduction



Conclusions

- Stagger angle affects level of blade participation
- Torsional frequencies and damping is affected by stagger angle
- FE approaches are all usable depending on required accuracy and available resources
- Field testing must be done under dynamic conditions
- DC motor & controller can be used for torsional excitation of small scale test rotors

Acknowledgements

- Prof. PS Heyns
- Dr. Abrie Oberholster
- Mr. Francesco Pietra
- Dr. Mark Newby
- Mr. George Breitenbach
- Mr. Herman Booysen
- Eskom Power Plant Engineering Institute (EPPEI)
- NRF Technology and Human Resources Programme (THRIP)