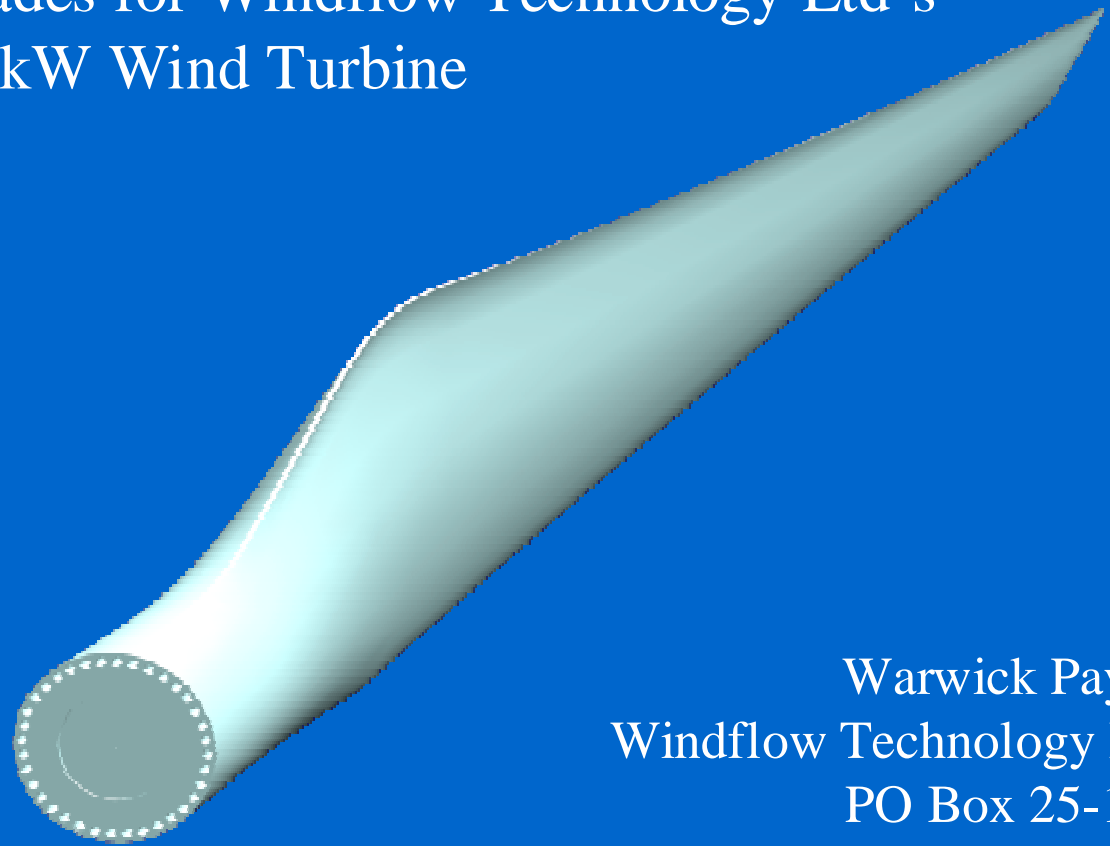


Windflow 500 Blades

New Zealand made blades for Windflow Technology Ltd's
500 kW Wind Turbine

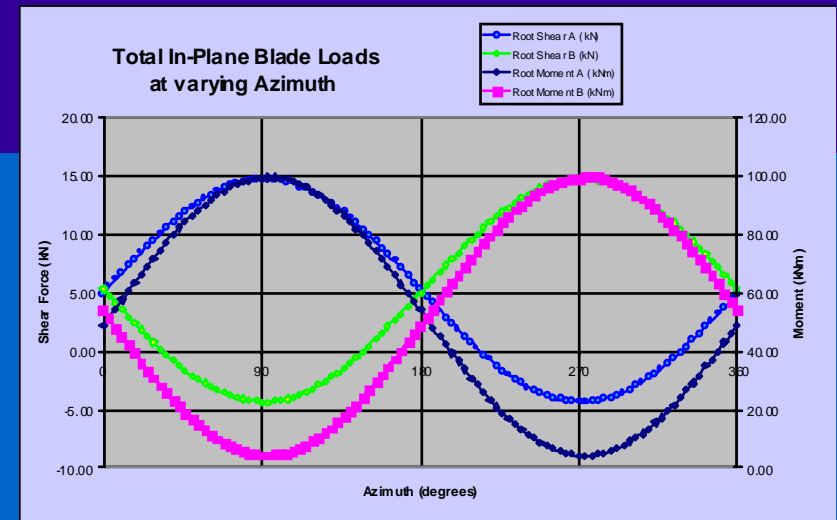
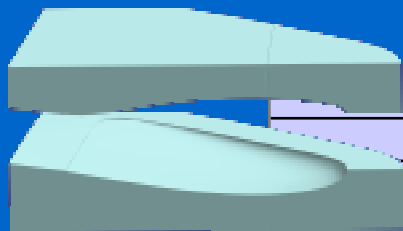
- Design
- Analysis
- Material Selection
- Material Testing
- Component Testing
- Mould Manufacture
- Blade Manufacture
- Blade Testing



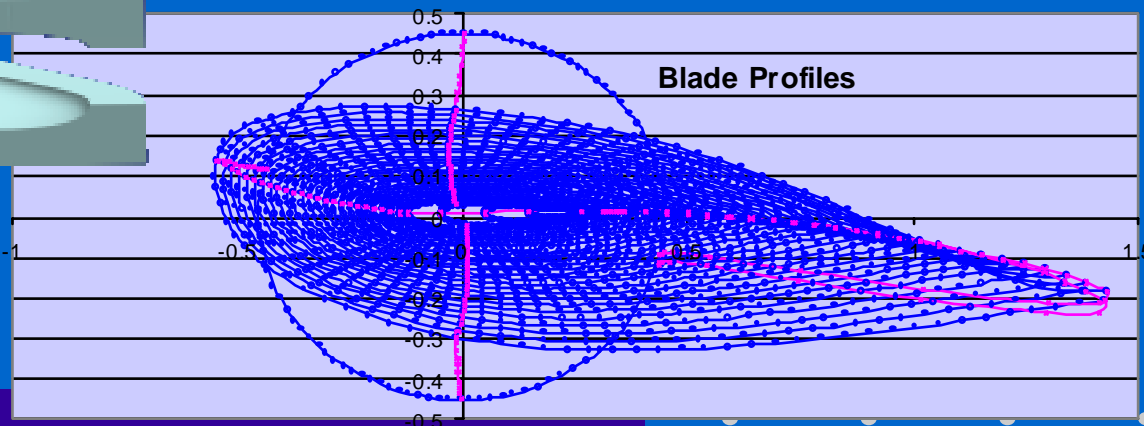
Warwick Payne
Windflow Technology Ltd
PO Box 25-131
Christchurch
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Design / Analysis

Blade Design — Spreadsheets have been an integral part of the design process. Our solid modelling package, SolidEdge, links directly with the spreadsheet (sample shown below). Any changes in the numerical blade profile are automatically updated in the solid model of the blade. The solid model is then used for many functions, including blade mould manufacture, tip mould manufacture (shown lower left), promotion material, design of shipping cradles etc.



Blade Analysis - As in the blade design, spreadsheets have been used extensively in the analysis of the turbine blades. Aerodynamic loads have been predicted using blade element theory as well as power output from the turbine. Stress analysis on the blade has also been performed using spreadsheets.



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Materials

Material Selection — Overseas wind turbine blades of similar size have been constructed from timber species not available in New Zealand (such as African Mahogany). It is preferable to use a New Zealand timber with similar or better material properties. From engineering references, New Zealand's Pinus Radiata seemed comparable.



Material Testing - Before we could use a new species of timber in our turbine blade, we needed more information (including statistical information) on the strength and stiffness of Pinus Radiata. Over 300 laminated samples were tested at the University of Canterbury. The results from this testing had low variability and showed that Pinus Radiata performed better than expected (from the engineering references). This is due to the rigorous selection process for the veneers, and also because using many thin veneers has an averaging effect on the laminate. These results have given us great confidence in using NZ Pinus Radiata for our wind turbine blades.

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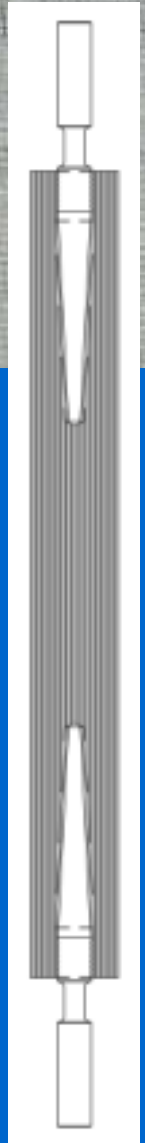
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Blade Attachment

Attachment Method - The wooden blades are attached to the pitch bearing using machined metal inserts “Carrots” as shown below. These are bonded into the blade end. The glue (or grout) that is used for this bonding has been designed by an Auckland firm who specialise in adhesives.



Grout Testing — Special Carrots were manufactured and bonded into a length of laminated timber using the new grout (as shown on the right). Two of these specimens were assembled for testing the grout strength. They were tested at the University of Canterbury last week. As you can see below the grout did not fail and it is stronger than the timber around it. The specimen below required 34 tonnes of load to pull it out of the timber. These results have exceeded our expectations.



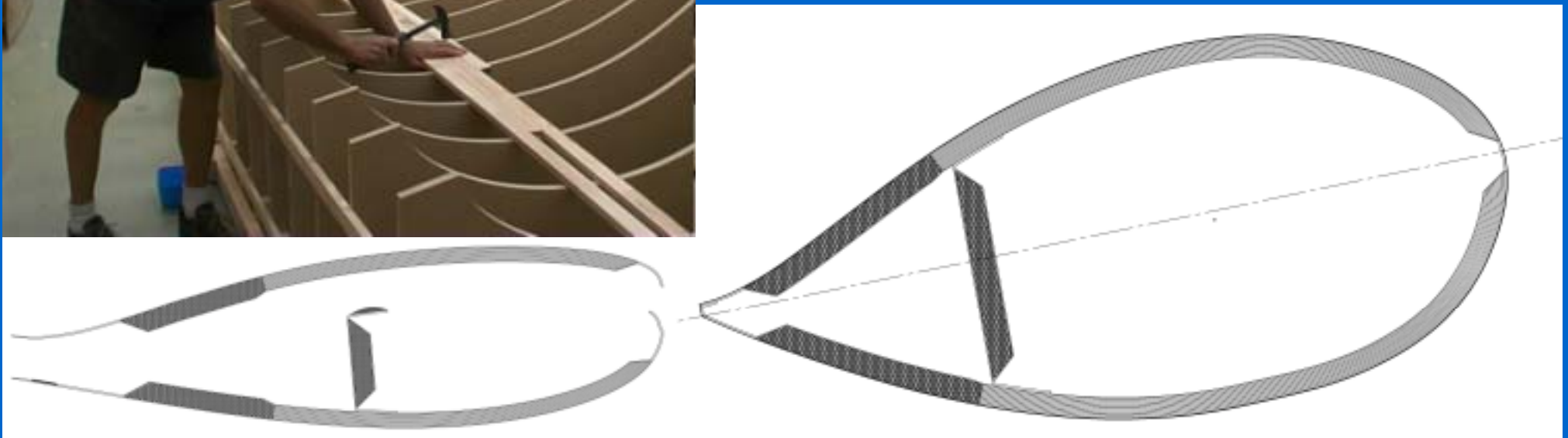
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Manufacture

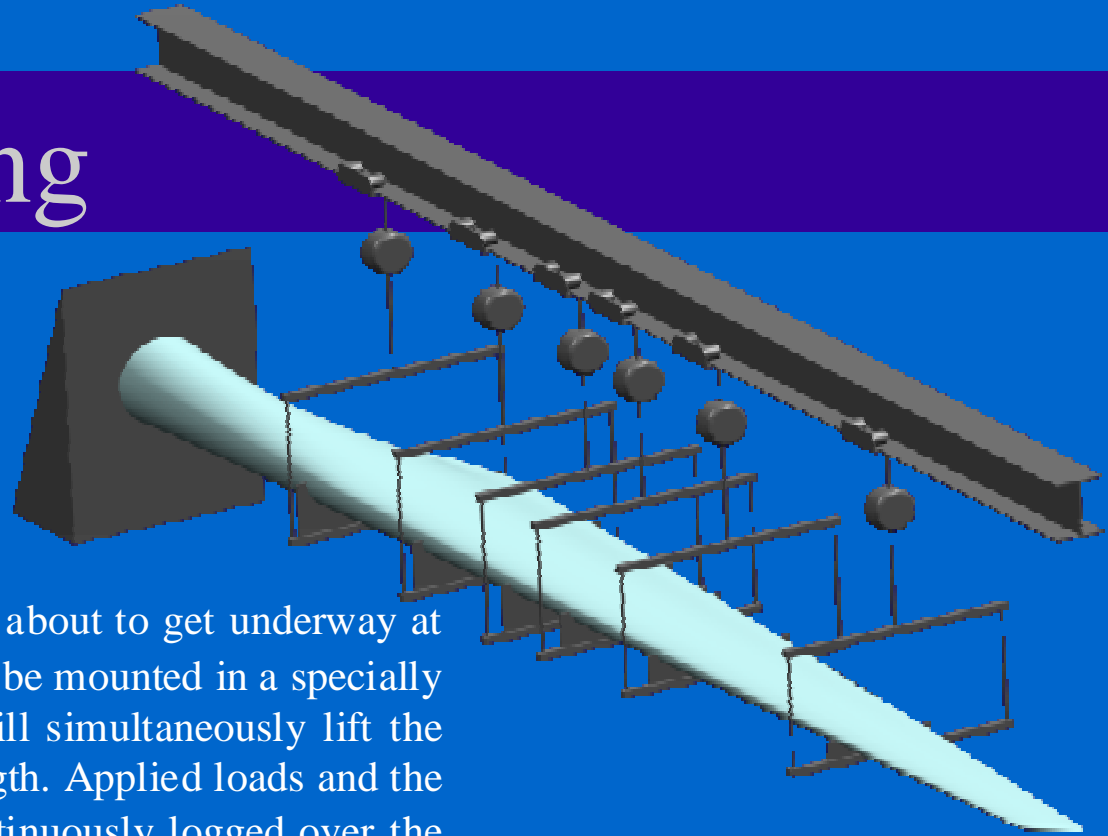
Mould Manufacture - The blade is formed in two female half moulds, then bonded together. The manufacture of the blade moulds is shown on the left. Wind Blades Ltd (an Auckland based company) constructed these moulds from MDF profiles (computer cut from our CAD model) which are then strip planked to form the blade shape. This method is similar to that used for boat building and we are drawing heavily on New Zealand experience in this field.



Blade Manufacture - Once the moulds are completed, the blade materials are laid into the mould and vacuum formed to the mould shape. Shown below are two cross sections of the blade. They are constructed from timber veneers laminated with epoxy resin. A fibreglass skin gives extra strength and protection. Styrofoam is used in non-structural areas of the blade to reduce blade weight and the cost of manufacture.



Blade Testing



Blade Testing - Full blade testing is about to get underway at the University of Canterbury. The blade will be mounted in a specially designed test rig. Six electronic winches will simultaneously lift the blade at six different locations along the length. Applied loads and the resulting deflections and strains will be continuously logged over the duration of the experiment.

The first part of the testing will be to proof test the blade. This involves applying 1 ½ times the maximum forces ever expected on the blades during 20 years of operation. Once the proof testing has been completed the blade will then be subjected to increasing load until it fails. This is estimated to occur at about 2 ½ times the expected maximum operating forces. Engineering design with timber is never an exact science and this test will give us invaluable information on both the timber properties and the efficiency of the blade design.