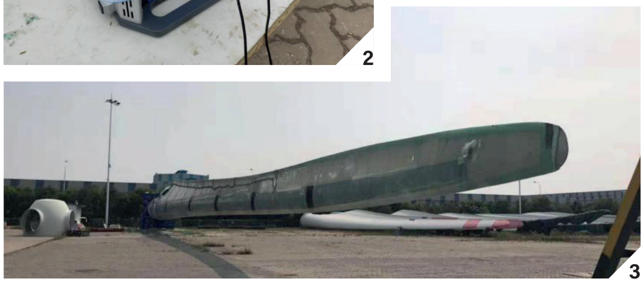
IMPACT MODAL TEST OF A WIND TURBINE BLADE

A project on a wind turbine blade shows how to improve impact testing of weakly damped structures



1 // The two accelerometers installed on the blade

2 // The acquisition front-end, a m+p Vibmobile used during the test

3 // The wind turbine blade under test

Wind turbine blades are one of the core components of a wind turbine. The cost of the blades accounts for 15% to 20% of total expense. Blade design directly influences the efficiency, productivity and economic benefit of a wind turbine generator. Wind turbine blades usually take a thin shell shape and are typically produced from glass fiber reinforced plastic. The main beam of the blade and its tip are typically reinforced with carbon fiber whilst the leading and trailing edge are made of interlayer structure composite material.

Data shows that wind energy availability increases by 12% as the diameter of blades increases by 6%. Nowadays the diameter of blades of a 2MW wind turbine generator can reach 80m, making the manufacturing, delivery and installation of wind turbines more difficult than in the past.

Usually, the nominal rotating speed of doubly fed induction generator is 30rpm (0.5Hz). As the diameter of the blades increases, their resonance frequencies or modal frequencies decrease. When the resonance frequencies approach the rotating speed, higher vibration levels occur and the wind turbine generator is subjected to higher alternating stress. Thus, the trailing edge of the blade will crack more easily and the service life will be shorter than the design value. So, it is important to consider the resonance frequencies already in the design phase of the wind turbine. Although the wind turbine design software takes the risk of blade resonance excited by rotating speed into consideration, a modal test is required to account for structural deviations from manufacturing and installation.

In December 2018, a team from m+p international was invited by a wind turbine company to do an impact test of a 60m-long wind turbine blade. The root part of the blade was installed horizontally onto a test bed through bolts, adjusting the direction in a way that the leading edge pointed down to earth and the trailing edge pointed up vertically, simulating the actual installation condition of the blade while it is in a horizontal position.

The first order resonance frequency was 0.48Hz, which was lower than the lower limit of a common ICP type accelerometer. To improve the quality of measured FRFs (frequency response functions), we used two low-frequency single-axis transducers, the sensitivity of which were 2.5 volts/g and 1 volt/g respectively. The lower frequency of these transducers is 0.3Hz which covers the lowest resonance frequency of the blade under test.

THE ESTIMATED MODAL PARAMETERS

Name	Frequency	Damping
Mode 1	0.4819782	0.735%
Mode 2	0.7476639	0.716%
Mode 3	1.328114	0.609%
Mode 4	2.126619	0.338%

The roaming hammer, fixed transducer method was used to run the test. Because the resonance frequencies of the structure were low, and the damping ratio relatively small, the duration to acquire a data block was set to 64 seconds to measure the complete vibration response of the blade and to gain a frequency resolution of 0.016Hz. For the impact excitation 32 different locations distributed evenly along the leading and trailing edge were used. The structure was excited by an impact hammer at each point in the vertical and horizontal direction.

After modal parameter identification, the team obtained the parameters of the first four modes as shown in table 1.

Obviously, the turbine blade is a weakly damped structure. The team from m+p international improved the widely used poly reference time domain method (PTD) to PTD plus to extract the modal parameters of such kind of weakly damped structures. PTD plus can obtain clean stabilization charts directly and effectively improve the quality of the results of the modal identification process even for unexperienced users.\\