Non-linear ultimate strength and stability limit state analysis of a wind turbine blade - DTU Orbit (15/12/2018)

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According to the design codes for wind turbine blades, it is sufficient to evaluate the blade's limit states using solely a linear analysis. This study, however, shows the need of non-linear analyses in blade design. Therefore, a geometrically non-linear structural response of a 34 m blade under flap-wise loading has been compared with a linear response to determine the blade's resistance in the ultimate strength and stability limit states. The linear analysis revealed an unrealistic failure mechanism and failure mode. Further, it did not capture the highly non-linear response of the blade that was measured in an ultimate full-scale test to failure and determined by a geometrically non-linear analysis. A design evaluation in accordance with the least stringent Germanischer Lloyd (GL) requirements has been compared with non-linear approaches proposed by GL and Eurocode, which require the application of an imperfection. The more realistic non-linear approaches yielded more optimistic results than the mandatory linear bifurcation analysis. Consequently, the investigated blade designed after the lesser requirements was sufficient. Using the non-linear approaches, considering inter-fibre failure as the critical failure mode, yielded still a significant safety margin for the designer (7–28%). The non-linear response was significantly dependent on the scaling of the imperfection. Eurocode's method of applying an imperfection appeared more realistic than the GL method. Since the considered blade withstood 135% of the design load at a full-scale test to failure and the blade has operated successfully in the field, GL's safety factors combined with the imperfection size may be too conservative. Copyright © 2015 John Wiley & Sons, Ltd.

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