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Elastic local buckling behaviour of ultra-long wind turbine blades with flexible core supports

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ABSTRACT

Ultra-long wind turbine blades, exceeding 100 meters, are characterized by their thin-walled cylindrically curved shells sandwiched by flexible core supports; buckling analysis is, therefore, crucial in the cross-sectional designing [1,2]. Conventional analytical solutions, which are based on models of compressive curved shells with simple or fixed supports [3,4], fail to account for the constraints imposed by flexible core supports. As a result, the buckling stability is under- or over-estimated, leading to either material waste or buckling occurrence. To address this challenge, this paper presents a study of the entire sandwich structure. Except for the existing modified Batdorf's parameter Z, which accounts for the curvature of curved shells, this study introduces a new dimensionless parameter β, which represents the ratio of the core web to the curved shell thickness, after eliminating the core web height h, which has a negligible impact on buckling loads. Although the elastic local buckling stress of the curved shell increased with the increase in both β and Z, but for the most common range of Z used in blades ($8 \leq Z \leq 37$), a range of β between 0.75 and 1.25 is recommended to balance buckling performance and material usage. This paper, then, identified a new suite of buckling deformation equations and developed an analytical equation based on the principle of minimum total potential energy to calculate the buckling loads of curved shells with flexible core supports by modifying that of simply supported, with the difference between analytical and validated numerical results being mainly in 10 %.

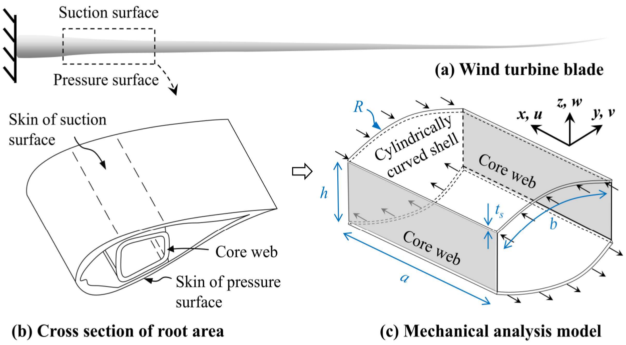

Figure 1: Structures of wind turbine blades and their mechanical analysis model.

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