Asl, M.E., Niezrecki, C., Sherwood, J. and Avitabile, P., 2019, Scaling and structural similarity under uncertainty, Conference Proceedings of the Society for Experimental Mechanics Series, Volume 3, 2019, pp.167–174. 36th IMAC, A Conference and Exposition on Structural Dynamics, 2018.

Abstract Fiber reinforced composite structures require extensive experimental evaluation for validation due to their heterogeneous properties and manufacturing variability. A scaled model replicating the structural characteristics of its full-scale parent structure facilitates and expedites the assessment of the mechanical performance of large composite structures. This study primarily investigates the problems associated with the design of a scaled model and its similarity to its full-scale parent structure when there is uncertainty in the design parameters. A successful design should be robust to its assumptions and the sources of uncertainty. In this study, scaled-down composite I-beams are designed from their reference full-scale I-beam representing the spar caps and the shear web structure inside a utility-scale wind turbine blade. Similitude analysis is used in conjunction with Info-Gap theory to design scaled composite I-beams under uncertainty in the design parameters. The scaling laws for the strain field of the composite I-beam are derived and used as a metric to design scaled models that are robust to the uncertainties in the design parameters. The range of influence of uncertainty in different design parameters is investigated. The effect of uncertainty on accuracy of the scaled model in predicting the strain field of the full-scale structure is studied under uncertainty in all design parameters and the strain field of the full-scale I-beam is predicated using that of the scaled model for the worst-case scenario.

Keywords Scaling, Similitude, Subcomponent, Uncertainty, Wind turbine blade.

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