Wind-Energy Science, Technology, and Research
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Engineered Sandwich Core Construction: Experiment & Evaluation

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Sandwich-structured composites dominate the blade manufacturing due to its high stiffness and light weight along the shift of wind power industry to pursue long turbine blades to extract more power economically. Core material used as the middle supporting component of a sandwich structure serves to decrease weight and enhance structural performance. Wet lay-up and resin transfer molding (RTM) processes are typical manufacturing processes for turbine blade construction, in which resin is introduced to the core-face system and then cured. The mechanical properties of sandwich components, processing characteristics, and property changes due to processing conditions are critical for the design and optimization of blade structures. However, during these processes, there is a lack of understanding of the amount of resin uptake, mechanical property changes following resin uptake, and the property spatial variation in the resin/foam or composite face skin/resin interphase region. Also, the mechanical property and the failure criteria of foam core and sandwich structures have not been investigated thoroughly. This project addresses these issues. In the project, an experimental investigation was carried out on the core foams under tension, compressive, and flexural tests. Digital image correlation technique was incorporated in these tests to provide an accurate deformation measurement to characterize the stress-strain response and failure behavior on two types of PVC foam. Then, wet lay-up and vacuum assisted resin transfer molding (VARTM) processes were used to manufacture core composite sandwich specimens consisting of PVC foam sandwiched by glass fiber face skins. The amount of weight gain due to the resin uptake in different processes was measured and its impact on the mechanical properties, specifically compressive modulus and strength, was studied. It is determined that higher resin uptake tends to increase the compressive modulus but decrease the compressive strength. However, higher resin uptake increases the specific compressive modulus but barely affects specific compressive strength. To understand the property variation at the interface between glass skin and foam core where resin is partially penetrates to fill foam pores, nanoindentation experiments were performed in the resin/foam transition zone. The spatial variation of Young's modulus in the transition zone was determined. The experimental results provide a quantitative understanding of how the material properties of sandwich cores are affected by the resin uptake in the RTM process and how the core sandwich composites fail under loads. The results also form a guideline for the design and optimization of manufacturing sandwich cores for turbine blades to lower levelized cost of energy (LCOE). All these data can also be fed into a FEM model to further optimize the design and to investigate the failure of core composite sandwich structures under service conditions.

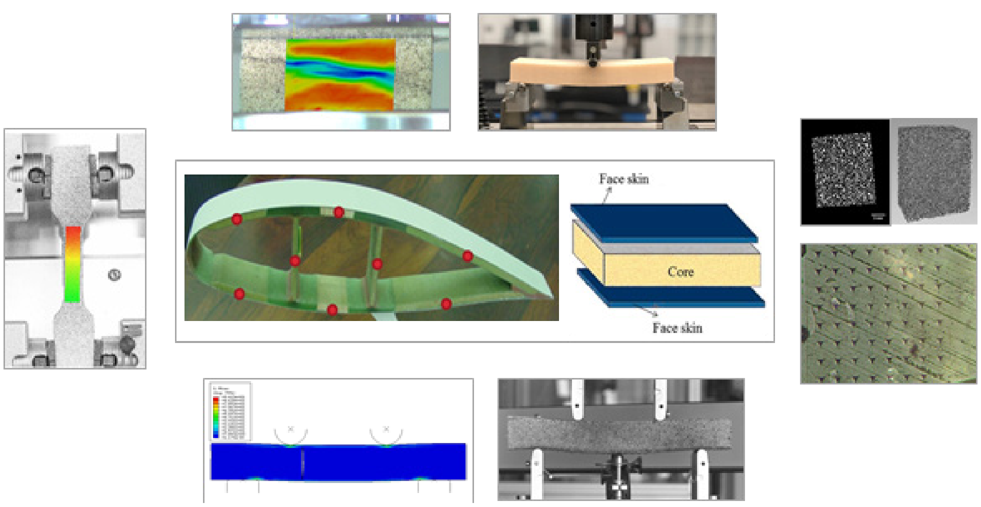

Figure 1. Experimental characterization of core foam, nanoindentation of resin/foam interface, and FEM simulation of sandwich under loading to facilitate the design and optimization of wind turbine blades.