# Failure Analysis of a Thick Composite Tidal Turbine Blade

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**Abstract**

This study is concerned with the failure analysis of a 5.25-metre composite tidal turbine blade under controlled static loading. Understanding the structural behaviour of these blades is critical for improving the performance and reliability of tidal turbines in an emerging energy sector still progressing towards full commercial deployment. While tidal turbine blades share many characteristics with wind turbine blades, their failure mechanisms differ due to a higher thickness-to-length ratio. In this work, we researched the primary factors contributing to blade failure, correlating both experimental and numerical analyses using strain data from sensors and digital image correlation (DIC). Static testing revealed that delamination was the predominant mode of failure, highlighting the importance of interlaminar stresses in thick composite structures. A 3D finite element model was developed to further analyse the failure mechanics of the blade, employing cohesive zone modelling to represent interlaminar failure and an element deletion framework to simulate the evolution of intralaminar failure. Well-established 2D modelling methods are computationally efficient, relying on plane stress conditions and thin structure assumptions, but neglect interlaminar stresses and out-of-plane failure modes. Building on this limitation, this research also evaluates the accuracy and computational efficiency of 3D modelling for composite materials, introducing an open-source tool that provides a high-performance framework for the finite element development stage.

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