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Unsteady Hydrodynamics of a Full-Scale Tidal Turbine

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The rotation of a tidal turbine blade through an unsteady flow field can induce stall delay, load hysterisis and dynamic stall, where the shedding of a leading edge vortex may cause overshoots in lift more than twice that of the quasi-steady value. The significance of these effects for a full-scale tidal turbine rotor operating in realistic wave conditions has yet to be quantified. To investigate, we develop a model which couples dynamic stall, rotational augmentation and blade-element momentum theory with real flow measurements taken during large waves. For a 9 m diameter rotor operating at an optimal tip-speed ratio of 4.5, we find that the flow field is dominated by waves and that flow separation and dynamic stall are confined to sections near the hub. Unsteady attached flow phenomena caused a reduction in the lift available at the outboard sections near the tip which decreased the power coefficient by approximately 3% compared to the steady state value.