

FULL-SCALE VALIDATION OF THE RANS K-EPSILON TURBULENCE CLOSURE MODEL FOR CAPTURING WHITEWATER REFORM IN THE SURF ZONE

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ABSTRACT

In the pursuit of recreating world-class surfing conditions, this study undertakes a comprehensive examination and accurate Computational Fluid Dynamics (CFD) modeling of surf-zone processes. The investigation centers on the impact of reef geometry on the ability to generate secondary reform surfing waves. Utilizing the Volume of Fluid (VOF) method, computational models are rigorously validated against field data obtained from the wave pool facility in Abu Dhabi, utilizing Kelly Slater Wave Co. technology. The findings underscore the significance of reef shape, with implications for reform wave surfing experiences in both coastal regions and man-made wave environments.

1. INTRODUCTION

The growing demand for inland surfing and the advent of artificial surf reefs necessitate effective tools for analyzing, optimizing, and verifying the design performance of surfing waves. This presentation explores the transformation of shallow-water waves, specifically secondary reform surfing waves, through Computational Fluid Dynamics (CFD) methods, supported by field data. Unlike traditional coastal engineering, which focuses on structural design conditions influenced by wave characteristics, this study concentrates on the analysis, optimization, and verification of the surf-zone waves itself, emphasizing its surfability aspect. The presentation provides a high-level overview of the design process behind the creation of the secondary reform wave experience for the Kelly Slater's Wave Pool project in Abu Dhabi, UAE.

2. RESEARCH METHODOLOGY

Formal scientific investigation underpinned the conceptualization, utilizing analytics, laboratory-scale, and CFD models. A CFD Finite Volume Unsteady Turbulent Moving-Mesh model, incorporating the Reynolds-Averaged Navier-Stokes equations and the K-Epsilon turbulence model, was employed. The Volume of Fluid (VOF) model, coupled with a Higher Order Differencing Scheme, facilitated accurate modeling of the free surface. Parametric CFD studies of different reef shapes were conducted, analyzing effects on key reform surfing wave quality aspects. Collaboration with the University of Southern California, Advanced Research Computing Center, contributed to fundamental CFD research cases.

3. RESULTS AND DISCUSSION

Upon implementation, a robust qualitative and quantitative correlation emerged between field measurements and laboratory and CFD studies. The

CFD results exhibited excellent agreement in simulating main wave generation and breaking, overturning jet splash-up, secondary reform wave generation and breaking, wave overtopping, damping, and energy dissipation. Optimized parameters for each bathymetry section ensured an ultimate reform surfing experience. The quantifiable aspects of the CFD reform wave aligned well with full-scale prototype data. This provides confidence that this model serves as a reliable tool for analyzing, optimizing, and verifying the design performance of surfing wave systems. It enables the examination of secondary reform surfing waves generated from whitewater resulting from the breaking of primary surfing waves, instilling confidence in its effectiveness.

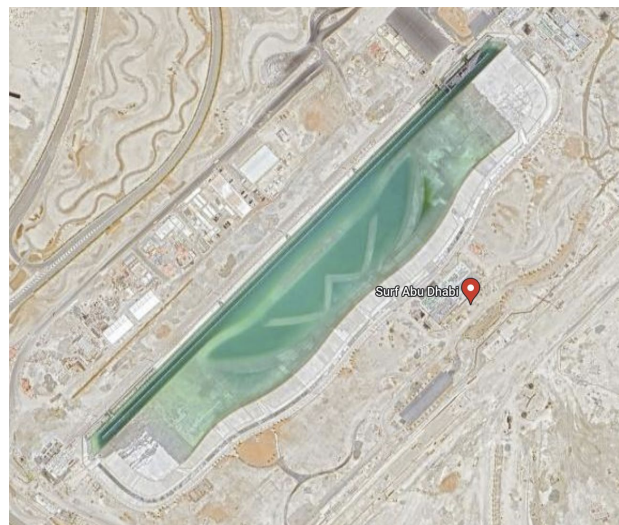


Figure 1 - Google Maps satellite image of the Surf Abu Dhabi basin with clearly visible main wave reef and incremental reform reef structures.