XI International Conference on Computational Methods in Marine Engineering

RANS modelling of heterogeneous roughness

Mridu Sai Charan Arukalava Seshasayee[1], Antonio Attili[1], Michael P. Schultz[2], Paul Hamblett[3], and Ignazio Maria Viola[1,*]

[1] School of Engineering, University of Edinburgh
The King's Buildings, Robert Stevenson Road, Sanderson Building Edinburgh, EH9 3FB, UK
[2] United States Naval Academy
[3] International Paint Ltd
[*] i.m.viola@ed.ac.uk

ABSTRACT

Studying the growth of boundary layers over rough surfaces and the consequent effects on skin friction and drag is essential for applications in fluid mechanics, such as the flow over ship hulls, aircraft wings, and atmospheric boundary layers. In these applications, Reynolds-Averaged Navier-Stokes (RANS) models are commonly employed to predict the wall shear stress and the velocity profile over rough surfaces. However, while it is established that RANS models can accurately predict the flow over smooth or uniformly rough walls, it is unknown, whether these models can predict the flow over step changes in roughness height. To this end, RANS is used to model previously conducted experimental studies of boundary layers over smooth and rough surfaces and surfaces with a streamwise step change from rough to smooth and smooth to rough. Results demonstrate good agreement with experimental data for velocity profiles and turbulent kinetic energy, both upstream and downstream of the transition, as well as in the region near the transition. The simulations also accurately predict the growth of the internal boundary layer, revealing how the boundary layer adapts to the new wall boundary. Furthermore, although the availability of experimental data for the skin friction coefficient across the rough-to-smooth transition is limited, the simulations show consistent results with those observed in other high-fidelity numerical studies in comparable conditions. Overall, this study reveals that RANS can accurately predict the mean flow field and kinetic energy over spanwise heterogeneous roughness and thus provides confidence in using these models for industrial applications. Further work is needed to verify the RANS accuracy in predicting the wall shear stress in the region near the roughness step change.