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Velocity-defect scaling for turbulent boundary layers with a range of relative roughness[1] MICHAEL SCHULTZ, KAREN FLACK, JONATHAN CONNELLY, U.S. Naval Academy — Velocity profile measurements in zero pressure gradient, turbulent boundary layer flow were made on a smooth wall and on two types of rough walls with a wide range of roughness heights. The ratio of the boundary layer thickness (δ) to the roughness height (k) was $16 < \delta/k < 110$ in the present study, while the ratio of δ to the equivalent sand roughness height (k_s) ranged from $6 < \delta/k_s < 91$. The results show that the mean velocity profiles for all the test surfaces collapse in velocity-defect form in the overlap and outer layer when normalized by the friction velocity obtained using two different methods. The velocity-defect profiles also agree within experimental uncertainty when normalized with the velocity scale proposed by Zagarola & Smits (1998). The results provide evidence that roughness effects on the mean flow are confined to the inner layer, and outer layer similarity of the mean velocity profile applies even for relatively large roughness.

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