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Turbulent boundary-layer flow over a long plate with a uniformly rough surface D.I. PULLIN, California Institute of Technology, N. HUTCHINS, D. CHUNG, University of Melbourne — We develop a semi-empirical model for a zero-pressure-gradient turbulent boundary layer flowing over a flat plate of length L and covered with homogeneous, uniform roughness of equivalent sand-grain roughness k_s. Use is made of the log-wake model for the stream-wise mean velocity that includes a transitional-asymptotic roughness correction together with the Kármán integral relation. For $Re_L = U_\infty L/\nu$ very large, the velocity ratio $S = U_\infty/u_\tau$ at $x = L$, the plate drag coefficient C_D and other mean-flow properties can be obtained for given Re_L and k_s/L. Three distinct cases are discussed; the smooth-wall, fully-rough and long-plate limits. Of these, the most important is the fully-rough case where k_s/L is fixed with $Re_L \to \infty$, giving that $C_D = f_1(k_s/L)$, $\delta_L/L = f_2(k_s/L)$ independent of Re_L. This agrees qualitatively with Granville (1958) although somewhat different $C_D(k_s/L)$ is obtained owing to the present use of a wake function. Thus for a given k_s and $x = L$ location on a fully rough vehicle, the boundary layer thickness and the drag coefficient is invariant with unit Reynolds number U_∞/ν.

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