Canonical inflow adverse pressure gradient turbulent boundary layers at high Reynolds number

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High friction Reynolds number (Re_τ) turbulent boundary layers (TBL) subjected to streamwise adverse pressure gradients (APG) are common in many engineering applications such as turbine cascades, ship hulls and aircraft wings. An important aspect of advancing our knowledge of such flows is understanding upstream history effects. Many previous studies have relied on working section inserts to establish the APG conditions, however, this invariably introduces complex boundary conditions upstream of the APG region. In the present study, we experimentally establish APG flows that originate from a high Reynolds number (canonical) zero-pressure-gradient boundary layer. This is achieved by adopting the methodology used in the pioneering study by Clauser[1], which permits a gradual streamwise increment in pressure in the test section by introducing a blockage at its outlet section.

The flow scenario is established in the large Melbourne wind tunnel[2] which permits precise control of the pressure gradient via air bleeds. The air bleeds are from spanwise slots in the tunnel ceiling, strategically located every 1.2 m along its 27 m long working section (Figure 1. (a)).

Figure 1(b) results give a pressure coefficient ($Cp = 1 - (U_1/U_o)^2$) distribution in a streamwise direction and acceleration parameter ($K = \nu/U_1^2 * dU_1/dx$) for three different cases. The APG velocity profiles are studied using traditional scaling analysis[3] and compared to the recent scaling approach of Wei & Knopp[4], which is based on the peak Reynolds shear stress profiles.

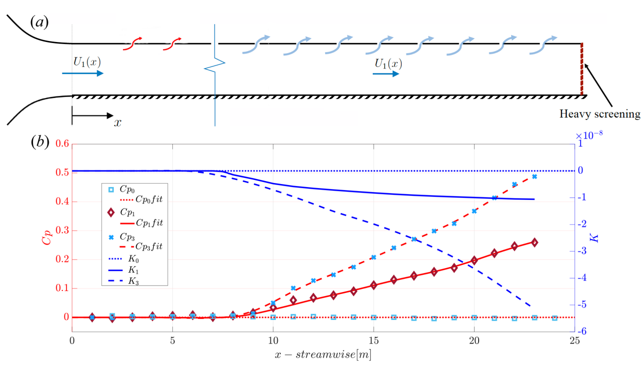

Figure 1: (a) Schematic of experiment setup. The length of the curved arrows on the test section ceiling is proportional to air flow rate bleeding through the ceiling. (b) Streamwise variation of Cp_i and K_i for a varying number of screens (i = 0, 1, 3) installed at the outlet.

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