Mapping Mean Velocity Field over Bed Forms Using Simplified Empirical-Moment Concept Approach	
Authors	**Mohamed Elgamal**
Publication Year	2023
Grant Number	IMSIU-RG23109
DOI link	10.3390/w15193351

Abstract: The log-wake law was successful in mapping velocity fields for uniform flow over flat surfaces, even in cases of wake effects (velocity dips, wall effects, and secondary currents). However, natural riverbeds with undulations and bedforms challenge these models. This study introduces a moment-based empirical method for rough estimation of the velocity fields over stationary 2D bedforms. It proposes three polynomial velocity profile templates (first, fifth, and eighth orders) with coefficients deduced analytically while taking into account an array of flow conditions and assumptions, including slip velocity at the bed, mass and moment of momentum conservations, imposing inviscid potential flow near the water surface, and incorporation of near-bed shear stress utilizing a moment-based Chezy formula. Remarkably, the coefficients of these polynomials are primarily reliant on two crucial velocity scales, the depth-averaged velocity (uo) and the moment-derived integral velocity (u1), along with the dimensionless reattachment coefficient (Kr). Validation of the proposed approach comes from ten lab experiments, spanning Froude numbers from 0.1 to 0.32, offering empirical data to validate the obtained velocity profiles and to establish the relationship of the spatial variation in the normalized u1 velocity along bedforms. This study reveals that the assumption of a slip boundary condition at the bed generally enhances the accuracy of predicted velocity profiles. The eighth-order polynomial profile excels within the eddy zone and close to reattachment points, while the fifth-order profile performs better downstream, approaching the crest. Importantly, the efficacy of this approach extends beyond water flow to encompass airflow scenarios, such as airflow over a negative step. The research findings highlight that linear velocity, as employed in Vertically Averaged and Moment models (VAM), exhibits approximately 70% less velocity mismatch compared to constant Vertically Averaged (VA) models. Moreover, the utilization of the fifth-order and eighth-order velocity profiles results in substantial improvements, reducing velocity mismatch by approximately 86% and 90%, respectively, in comparison to VA models. The insights gained from this study hold significant implications for advancing vertically averaged and moment-based models, enabling the generation of approximate yet more realistic velocity fields in scenarios involving flow over bedforms. These findings directly impact applications related to sediment transport and mixing phenomena.