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Estimation of Reynolds shear stress using 3D velocity fluctuation in Vortex Settling Basin

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Abstract

This paper presents the results of an experimental investigation on Reynolds shear stress using three-dimensional velocity fluctuation in flow field of vortex settling basin. An ADV (Acoustic Doppler Velocity Meter) were used to measure 3D velocity components inside the basin. The cylindrical grid of data acquisition was designed to do detailed measurements. Presentation of radial, tangentially and vertically shear stress trough contour type graphs in radial sections shows both positive and negative magnitudes of Reynolds stress having high magnitudes in vicinity of central air core, side wall and chamber bed and low magnitude in other regions of flow body. The influence of overflow exiting jet in radial shear stress is notable. The region surrounded with 25 cm radial distance from basin center and 10 cm height is a zone that the magnitude of tangentially and vertically shear stress is high with negative singe independent to the position of entrance flow jet and overflow exiting jet. It seems this conclusion is the overcome of turbulence intensity in vicinity of central flushing orifice.

Keywords: Vortex Settling Basin, 3D Velocity Distribution, Velocity Fluctuations, Reynolds stress.

1. INTRODUCTION

Different types of sediment extractors/excluders, such as tunnel type, vortex tubes, rectangular settling basins and vortex type settling basins are often employed for purpose of sediment extracting/excluding. In recent years the vortex settling basin (VSB) has attracted a considerable interest among the water engineers. The vortex settling basin (VSB), is a continuous device which applies a certain fraction of flow for flushing the sediment particles out of the diverted stream [1]. VSB utilizes centrifugal forces to generate a vortex motion around its central axis to remove sediment particles from the incoming flow by means of secondary currents in the chamber through the central flushing orifice [3]. In this device the high velocity flow is introduced tangentially into cylindrical basin having an orifice at the center of its bottom. [4]. Resulting secondary flow causes the flow layers adjacent to the floor of the basin moving towards the central outlet orifice. Therefore, the sediment particles reaching the center of the chamber could be flushed out continuously through the orifice and a relatively sediment free water would leave the basin through its overflow weir crest [5].
The flow behavior in this device is so complex due to turbulent nature and secondary currents of flow field. It is believed that better understanding of sediment trapping in such structures is dependent to understanding of turbulence nature of flow in the basin. Limited researches have been carried out previously on flow structures of these type extractors. However, turbulence characteristics in the basin remain unexplored.

The vortex settling basins have been investigated principally by Vokes and Jenkines (1943), Velioglu (1972), Salakhov (1975), Cecen and Bayazit (1975), Sulivan et al. (1978), Curi et al. (1979), Mashuri (1981,1986), Svarovski (1981), Ogihara and Sakagouchi (1984), Sanmogantan (1985), Zhou et al. (1989, 1997), Paul et al. (1991), Ziaei (2000, 2001), Athar et al. (2002, 2003), Keshavarzi and Gheisi (2006) [2].

Most of these investigations in their experimental studies tried to focus on the trap efficiency of the vortex settling basin and express an appropriate relationship for its estimation.

Secondary currents were generated in the vortex settling basin as a consequences of the effects raised from (i) entering water jet, (ii) over fall water jet from the curved weir crest and (iii) the bed slope of the basin towards the central orifice