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Sediment Extraction and Flow Structure of Vortex Settling Basin

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Abstract

The paper presents the results of an investigation conducted in a vortex chamber and the flow structure along with sediment extraction efficiency were observed. During the experiments, various flow discharges were employed. Three sizes of sediment were fed at three different rates. It was observed that the increase in the flow and sediment feeding rates result in the increase of sediment extraction efficiency of the settling basin. An ADV velocity measuring equipment was utilized to determine flow structure inside the settling basin. It was also found that various types of flow patterns were developed in radial sections which may play a positive or negative role in sediment trapping process.
Keywords: Sediment extraction; vortex chamber; extraction efficiency; flow structure.

1. INTRODUCTION

Sediment deposition in diversion canals is one of the most severe problems which the designers and operators are often faced with. Sediment laden flows are capable to transport and deposit a considerable rate of sediment loads in the conveyance channels which results in reduction of conveyance capacity of the system. Different types of sediment extractors/excluders, such as tunnel type, vortex tubes, rectangular settling basins and vortex type settling basins are often employed for this purpose. 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 (Gard and Ranga raju, 2000). Classical settling basins generally suffer from two main disadvantages: (i) requirement of large dimensions of basin compared with other types, and (ii) longer settling time for sediment particles. Sediment extractors of vortex type would overcome the mentioned disadvantages (Keshavarzi and Gheisi, 2006). 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 (Ziaei, 2000). In this device the high velocity flow is introduced tangentially into cylindrical basin having an orifice at the center of its bottom. This gives rise to the combined vortex conditions (Rankine type) having a forced vortex near the orifice and a free vortex at the outer region towards the periphery of the basin. As a result, sediment concentration gradient builds up across the vortex and a diffusive flux, proportional but opposite to the centrifugal flux, is induced (Athar et al., 2002). 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 (Mashuri, 1986). 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), Keshavarz and Gheisi (2006).

In the present study, the diaphragm and the deflector were eliminated to solve the problem of sediment deposition on their top surfaces. Despite the other investigators, the height of the entrance orifice was decreased by 30% which resulted in a high velocity of entrance flow jet.

A strip type sediment feeder was employed throughout the experiments to overcome the disadvantages of unsteady feeding and point feeding of sediments recommended by the previous researches.