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EFFECTS OF ENTRAINED AIR MANNER ON CAVITATION DAMAGE*

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Abstract: Early in 1953 the experiments by Peterka proved that air entrainment has effects on decreasing cavitation damage. This technology has been widely used in the release works of high dams since the inception of air entrainment in the Grand Goulee Dam in 1960. Behavior, mechanism and application of air entrainment for cavitation damage control have been investigated for over half century. However, severe cavitation damage happened due to complex mechanism of air entrainment. The effects of air entrainment are related to many factors, including geometric parameters, hydraulic parameters and entrained air manners. In the present work an experimental set-up for air entrainment was specially designed, the behavior of reducing cavitation damage was experimentally investigated in the three aspects of entrained air pressure, air tube aera and air tube number. The results show that magnitude of reduction of cavitation damage is closely related to the entrained air tube number as well as entrained air pressure, air tube aera, and that the effect through three air tubes is larger than that through single air tube although the entrained air tubes have the same sum of tube aera, that is, $1+1+1>3$. Therefore, it is important to design an effective manner of air entrainment.

Key words: air entrainment, air pressure, air tube area, cavitation damage, entrained air manner

Introduction

Air entrainment is a kind of effective and inexpensive measure to reduce cavitation damage. Early in 1953, Peterka conducted experiments to investigate the effects of air entrainment on the modification of cavitation damage. The finding revealed the cavitation damage of the material is greatly decreased when the air is entrained into the water on the surface of materials[1]. This is an important discovery and very useful for the development of the technology and application of cavitation damage control. In 1960 air entrainment was successfully used in the Grand Goulee Dam in America and at present this technology is applied in almost all the release works of high dam for the decrease of cavitation damage[2].

The effects of air entrainment are related to many factors, including geometric and hydraulic parameters, and entrained air manners. Most of researches in the past focused on the effects of air concentration and, the form of aerators on the prevention from cavitation damage. The cavitation damage could be effectively reduced when the air concentration of 3-5% is provided in the flow on the surface of the materials. In the applications of entrained air technology, many kinds of aerators have been developed, such as U-type, V-type[3], dentform, and A-type downstream behind ramps[4] as well as the traditional forms with combinations of ramp, step and grove. All the purposes of the development of the different forms of aerators are to keep some air concentration on the interface between flow and structural surface to meet the working conditions of different release works, especially for the flow with either low flow Froude number[5] or small bottom slope of a spillway[6]. The air concentration has been paid attention to, and the estimation of cavity length (L) for the design of an aerator is an important issue since air flow (q) is directly related to flow velocity (V_o) and L, i.e., $q=kV_oL$ [7]. The control of the filling water in a cavity is another item due to affecting the effective cavity length[8,9]. Chen et al.[10] presented an idea that small air bubbles have better effects on the reduction of cavitation damage through

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