Erosion Caused by Cavitation in Bottom Outlets, Cambambe Dam Case, Angola

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Abstract. The hydroelectric Cambambe is in the middle section of the Kwanza River, the main river of Angola, about 113 miles from the capital Luanda. The dam was built in the 60s by SONEFE (National Society for the Study and Overseas Business Finance) with detailed hydraulic studies by LNEC (National Civil Engineering Laboratory) in Lisbon [Palu et al., 2010]. The Cambambe hydropower dam started its operation in 1964 [Salles et al., 2011]. The arrangement of the structures of this plant consists of a concrete dam with double curvature arch type, with 190 ft height and 1080 ft in length, a power generation circuit composed by a gravity type intake, conveyance tunnels and an underground powerhouse. The existing spillway is of broad crest type, 328 ft long located in the body of the dam. Additionally, there is a bottom outlet on the right bank with the function of divert the river during the dam construction and provide a sediment release downstream on the reservoir operation. The tunnel has a total length of 1716 ft and two gates; a caterpillar gate upstream (14.8 ft large and 22 ft height) for maintenance and a segment gate downstream (11.5 ft large and 19.7 ft height) to control the flow. Downstream of the segment gate the tunnel has an arc rectangle section of with a width of 19.7 ft and height of 24.6 ft, with a concrete lining on the bottom and on the walls. After 40 years of continuous operation of the plant, the works for the rehabilitation and expansion begun in 2004, leading to raising existing dam by 66 ft. At the beginning of the rehabilitation, engineers conducted an inspection in the bottom outlet tunnel. On that occasion, they noted the occurrence of a large scour hole downstream of the segment gate. The scour hole was about 130 ft long and 46 ft high. Such erosion had been caused due to cavitation, since the flow velocity downstream of the gate segment reached approximately 115 ft/s. The solution was the installation of a side slot aerator with a ramp. The function of the aerator is to inject air in the flow, since the concentration in air stream can mitigate or completely avoid the harmful effects of cavitation [Pinto, 1986 and Falvey, 1990]. Similar solutions had been applied to other dams like Tarbela Dam in Pakistan and Colbun Dam in Chile [Palu et al., 2010]. After the conceptual design, the aerators were tested in a physical model (Bardella – Brazil) and it worked well. Finally, it was successfully built on site.

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