doi:10.20396/revpibic.v0i0.id

EQUIPAMENT TO AVALIATE EROSION CAUSED BY WATER-SOLID MIX ON HYDRAULIC SURFACES

Guilherme R. Gallani*, Renan de L. Branco, Stefano Malavasi, José G. Dalfré Filho.

Abstract

The surfaces of hydraulic structures may suffer erosion damages caused usually by abrasion or cavitation. Abrasive erosion is caused by the friction and the impact of water-solid mix and in cavitation erosion, bubbles implosions can lead to huge erosion, and many other related problems. In order to guarantee the safety of the structures, both effects must be analyzed. Different concretes may present several performances when exposed to abrasion and cavitation erosion. Therefore, this research evaluated the effect of differents coarse aggregates on concrete resistence to erosion by abrasion and by cavitation.

Key words: *water-solid mixture, cavitation, hydraulic structures.*

Introduction

The Brazilian Dam Safety Report (ANA, 2016) reveals that most of the hydroelectric power plant problems are related to the dam itself and to the spillway erosion, with high costs to repair. Tatro et al. (1992) analyzed several cases of eroded structures and 82,3% of the cases showed abrasion damages. According to Liu et al. (2006), friction and impact of suspended solids occasioned concrete abrasion. After eroding the mortar, the coarse aggregates exposure allows increase of erosion, when they are extracted. Since concrete strength depends on several variables and the coarse aggregate exposure affects the abrasive and the cavitation resistance, this research aims to examine the effect of different coarse aggregates on erosion resistance. To achieve a better understanding of the results, the equation of Horzczaruc (2004) was used. It relates the concrete relative mass loss over time: $\frac{\Delta M}{M_0} = 1 - (\frac{a}{a+t})^b$ (1), or the mass loss rate $\dot{E} = M_0 \frac{b}{a}$ (2).

Results and Discussion

Equation (1) for the abrasive erosion, when using basaltic coarse aggregate #0 leads to Equation (3), implying in a mass loss rate of 9,6g/h, while for basaltic #1 leads to equation (4), with 11,3g/h mass loss rate. For cavitation erosion, mass loss rate was 642,8g/h, see Equation (5).

$$\frac{\Delta M}{M_0} = 1 - \left[\frac{10,092}{10.092+t}\right]^{0.009} \quad (3)$$

$$\frac{\Delta M}{M_0} = 1 - \left[\frac{8,966}{8,966+t}\right]^{0.010} \quad (4)$$

Figure 1 shows the erosion in time for both aggregates submitted to abrasion erosion.

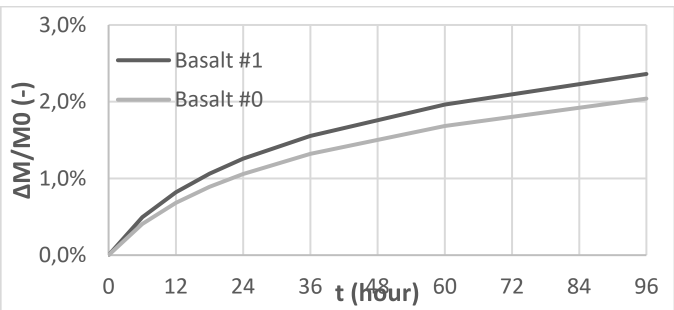

Figure 1. Abrasive erosion mass loss rate

$$\frac{\Delta M}{M_0} = 1 - \left[\frac{0.0684}{0.0684+t}\right]^{0.019} \quad (5)$$

Figure 2 shows the erosion evolution in time for basaltic coarse aggregate #0, submitted to cavitation erosion.

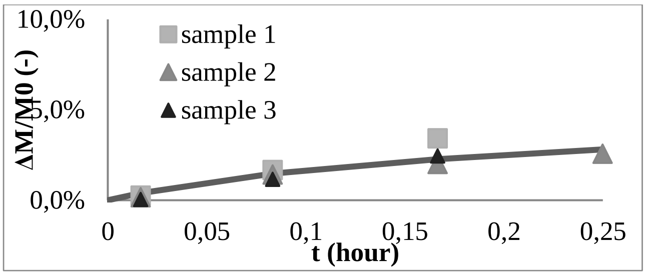

Image 2. Cavitation mass loss rate

As each sample takes seven to eight weeks to be tested both in the abrasion equipment and in the cavitation equipment, other tests are still being conducted.

Conclusions

Cavitation showed highly aggressive erosion, with higher mass loss rate and concentrated damages, while abrasive erosion showed lower rates, with distributed damages and long-term effects, justifying the present situation found on hydraulic structures, when its being neglected due to the long time appearance of problems. In respect to coarse aggregate effects, the concrete with basalt #1 showed a mass loss rate of 17,8%, higher than the concrete with basalt #0. Therefore, in a hydraulic structure, the basaltic coarse aggregate #0 must be chosen, increasing the structure lifetime.

1-ANA. Relatório de Segurança de Barragens 2016. Brasília: Agência Nacional de Águas; p. 28-29, 181. 2016.

2-HORSZCZARUK, E. The model of abrasive wear of concrete in hydraulic structures. Wear, v. 256, n. 7, p. 787-796, 2004.

3-LIU, Y. W; YEN, T.; HSU, T. H.; Abrasion erosion of concrete by water-borne sand. Cement and concrete Research, v. 36, n. 10, p. 1814-1820, 2006.

4-TATRO, S. B. et al. Compendium of Case-Histories on Repair of Erosion-Damaged Concrete. ACI Materials Journal, 33p., 1999.