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Statistical quality control method for automated water flow measurements in concrete dam foundation drainage systems

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Abstract

Seepage through the foundation is a relevant condition for the structural assessment of concrete dams. The knowledge of the water flow measured in the drainage system installed to reduce the uplift pressure in a dam's foundation is, therefore, a main issue in the safety control of concrete dams. Monitoring systems include measuring devices to determine the water collected from drains and weirs in order to evaluate the amount of water that flows through the dam. In most large concrete dams, both manual and automated water flow measurements are possible.
This paper proposes a statistical quality control method for automatic measuring systems based on simultaneous manual water flow measurements and the knowledge of the corresponding measurement uncertainties. Experimental tests performed in a weir of a Portuguese concrete dam are described and paired water flow estimates and corresponding measurement uncertainties are presented and applied to the proposed method. The results of this study show that the method allows statistical quality control of automated water flow measurement systems applied in concrete dam drainage systems.

1. Introduction

The majority of recorded failures in concrete dams, not including issues related with appurtenant structures, are due to problems in the foundation, such as erosion and internal dissolving of rock masses, which often lead to a loss of strength and lack of shear resistance in weak planes of unfavorable direction [1].

Concrete dams are always founded in rock masses, characterized by a significant number on discontinuities or joints, which are very important for the mechanical and hydraulic behaviour of the foundation. Despite impermeabilization works done during construction in the foundations to minimize the water flow, leakage and seepage occur in all concrete dam foundations. The amount of water flow is a function of the reservoir level, watertightness of joints, foundation permeability, reservoir and ambient temperatures, and grout curtain or cutoff effectiveness [2].

Continued measurement of seepage can provide an indication of progressive dissolution or erosion in a dam foundation or abutment [3]. The types of measurement instruments used to monitor seepage include weirs, flow meters and standard recipients [4].

In general, manual measurements of the water flow in the drainage system is obtained by an operator from the filling time measurement of a standard recipient with known volume. In this paper, this measurement system is denoted as Manual Data Acquisition System (MDAS).

Measurement estimates from MDAS are subjected to an in situ quality control procedure, being compared with previously defined threshold values. These control limits allow the detection of gross measurement errors and are established taking into account the measurement range and extreme values observed in prior records [5].

Many large concrete dams also operate with Automated Data Acquisition Systems (ADAS), which allow water flow measurements in weirs without direct human intervention [1,6,7]. This measurement system has the advantage of performing continuous measurements, being a fundamental tool for real time safety control of concrete dams. Therefore, a high level of confidence in the obtained automatic