Design of Quality Assurance Program to Validate Dam Foundation Grouting

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The Mosul Dam karstic foundation consists of multiple layers of gypsum/anhydrite interbedded with limestone, brecciated marl and other rock layers at various depths below the embankment extending to depths of up to 300 meters. The dissolvable nature of Gypsum could result in voids and collapses leading to stoping, internal erosion, etc. that could compromise the stability of the dam. The karstic nature of the foundation has required continuous maintenance grouting since the dam was completed - for the last 35 years. However, concerns about the deteriorating foundation of the dam and the significant consequences of its failure lead to the implementation of an emergency grouting program in 2016-2019 to stabilize the dam. This paper focuses on the design of the Quality Assurance (QA) program implemented to ensure quality, monitor the foundation response to grouting, and to provide timely feedback for improvements to the grouting program. The QA program included the use of real time automated monitoring of grouting volumes and pressures, grout sampling/testing, water pressure tests, rock coring, down hole close circuit TV cameras, optical and acoustical televiwers, etc. The QA program validated the quality of the injected grout and grouting processes. For example, grout quality within 2-3 KM pumping loops under 120 oF ambient temperatures and the difficulty of injecting grout under high artesian pressures and outflows (>10 bars and >250 l/sec) constantly challenged the operations. The study of issues related to grout drop/settlement, grout setting, difficulties in reaching refusal, hole collapses, etc. were studied which led to improvements to the grouting methods. Additionally, given the emergency nature of the grouting program, there was limited knowledge of specific foundation conditions at every location along the length of the dam. The QA program helped fill in many of those critical data gaps which in turn allowed timely modifications to the overall grouting program.