Spillway Investigation and Emergency Works at Lower Carno Reservoir

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SYNOPSIS. Lower Carno Reservoir dates from 1911 and supplies water to the town of Ebbw Vale. The reservoir is impounded by a 27 m high Pennine dam across the River Ebbw. Substantial works were carried out in 2010 to address significant leakage through the core and foundation, resulting in the construction of a plastic concrete diaphragm wall through the core and foundation grouting around the culvert (Rowland et al, 2008, 2009).

The reservoir was inspected in 2015 under the Reservoirs Act, resulting in various measures *in the interests of safety*. The Inspecting Engineer recommended the masonry spillway chute be re-pointed and measures taken to minimise uplift pressure beneath the channel.

Investigations were carried out in 2018 to assess the condition of the backing to the masonry chute, which revealed that the concrete beneath the channel was voided and of poor quality, while the backing to the walls was relatively intact. A review of the hydraulic loading on the structure identified PMF velocities approaching 20 m/s and the risk of plucking of masonry blocks and erosion of the embankment mitre was judged to pose a significant and credible threat to the safety of the reservoir. In light of this information, a decision was taken by the Owner, in conjunction with the QCE, to drawdown the reservoir so that the spillway did not operate until the masonry chute was replaced with a modern structure.

This paper will describe the investigations, emergency drawdown, dam safety management plan, key aspects of the spillway design and its construction.

Earthquakes and Dams: Remote and direct monitoring of the effects of UK seismic activity on reservoir infrastructure.

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Whilst in a Global context seismic hazard in the UK is low, it is not absent, and earthquakes have the potential to negatively affect reservoir structures. Since 1990 the UK has experienced more than 13 earthquakes of greater than magnitude 4, two of which were above magnitude 5. There is also the potential for much smaller earthquakes to produce levels of ground motion that could be of concern; for instance if they are unusually shallow or otherwise close to a structure of interest. Since 1839 there have been 3 documented cases of earthquakes causing damage to UK reservoirs. Our earthquake hazard is also complicated by having both naturally occurring earthquakes, and ones induced by human activity. In this talk two different, but potentially complimentary, methods of monitoring reservoir infrastructure for the effects of earthquakes are considered. These are;

a) Remote monitoring of a region with a rapid alert system for notifying reservoir operators, together with the use of ground motion prediction equations to assess the likely ground motions at the facilities of interest.

b) Direct emplacement of seismic sensors into reservoir structures to provide absolute values of ground motion during an earthquake, linked to an alarm system to alert operators, where appropriate.

This talk is focused on the UK, including a number of examples of different companies using earthquake information to intelligently manage their reservoir assets. However, the described methodology is equally valid outside the UK.

Rhodeswood Reservoir – A combined approach to the investigation and remediation of an ageing asset

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Rhodeswood reservoir is the third of five reservoirs within the Longdendale valley cascade. Standing 25m high, it has a central puddle clay core and a unique profile as a result of the complex geology and history of landslips within the valley. Limited historical drawings and ground investigation data suggest a steep interface between the core and rock, described as 'shaken ground', at the northern abutment. This has resulted in a branched puddle trench and upstream blanket wrapping around the northern upstream abutment area. United Utilities undertook a routine assessment of the risk of internal erosion to the dam. This identified an intolerable risk of scour at the abutment/core interface, which was supported by a history of seepage within this area.

This paper details recent combined investigation and grouting remedial works, targeting the interface between the core and heavily broken and voided rock abutment. Through collaborative working and a flexible programme of works, confirmation of ground conditions and subsequent development of a detail ground model was achieved. This identified zones of high permeability within the rock abutment but also loss of fines and flush water at this core to foundation interface. A focused grouting solution using ascending stage and Tube-a-Manchette techniques, to target the core to foundation interface, was adapted for the conditions encountered. Additional challenges included inclined grouting around the reservoir siphon pipe which was situated within the grout zone and the containment of grout and flush water on the crest due to the sensitive nature of the surrounding environment.

Elton Reservoir Slip and Spillway Works

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Elton Reservoir was built between 1804 and 1808 to supply water to the Manchester, Bolton and Bury Canal. This is now no longer in use but the reservoir does provide a sweetening flow. The reservoir is retained by a 600m long embankment dam with a maximum height of 8.8 metres, has a capacity of 923,000 m^3 and a surface area of 22 hectares. Top Water Level in the reservoir is 87.70 m AOD.

The reservoir has experienced a number of embankment slips in the past with the most recent in 2012, at which time the water level was drawn down until repair works could be undertaken. There was also a length of unlined spillway channel, downstream of the main spillway, where some erosion had occurred on the right bank leaving an unsupported vertical bank up to 700 high. As these issues where being addressed the opportunity was taken to complete other remedial works including making the operation of the scour valve within the confined space of the outlet tunnel less onerous.

This paper will discuss:

- The investigation works undertaken including piezometer installation and monitoring of water levels and subsequent stability analysis.
- The various options considered with respect to repairing the slip and providing embankment stabilisation.
- The preferred solution of counterfort drains and subsequent construction of the works.
- Other works also undertaken including bank protection works to the channel downstream of the spillway and the installation of a remote operating system to a new scour valve.