Seathwaite Tarn Reservoir

repairs to a remote reservoir in Cumbria

Seathwaite Tarn is situated about 4 km north east of the village of Seathwaite in Cumbria. The reservoir was built in 1907 and has a capacity of 2,945Ml. Water is discharged to Fern Beck downstream of the dam and abstracted from the River Duddon at the treatment works at Ulpha in the Duddon Valley. Two dams separated by a rock knoll retain the reservoir. The 'main' dam is 138m long and 9m high, and is composite in construction and curved in plan. It is formed with a concrete gravity section on the right side (north) and an embankment section on the left side (south) with a concrete core. The embankment was built from clayey sand and gravel with some cobbles and boulders. The 'subsidiary dam' located to the north of the 'main dam' is a concrete gravity dam that incorporates the auxiliary overflow.

Aerial view, upstream face of concrete dam and auxiliary overflow showing temporary access and Carpi Membrane *Courtesy of Eric Wright Civil Engineering Ltd and MWH*

Inspection

A statutory inspection was completed by the All Reservoir Panel Engineer in January 2007 during which the Panel Engineer recommended that works be carried out to the concrete face of the dam and that additional measures be implemented to prevent further deterioration of the concrete. Following this recommendation, United Utilities commissioned MWH to undertake works to improve the condition of the existing concrete dams and to help to implement recommendations to ensure that the reservoir would meet the requirements for a Category A reservoir.

The project team

The Seathwaite Tarn Reservoir project was part of United Utilities' £2.9 billion programme investment in water quality and environmental improvement between 2005 and 2010. MWH UK Ltd provided solution identification and detailed design as well as procurement services, construction support, and CDM Coordinators. Eric Wright Civil Engineering Ltd was the main contractors for the £1.5m project, and Carpi Tech from Italy was the specialist waterproofing contractor.

The problem

A Condition Survey of the downstream face of the concrete dam concluded that the face of the main dam was in a very poor condition.

The following issues were identified in the survey:

- Spalling of the face of the dam;
- Lifting at construction joints;
- Map cracking;
- Water could be seen running on the face from the opened construction joints;
- Freeze/thaw and other thermal effects had caused the face to deteriorate;
- Evidence of alkali silica reaction.

In addition to the poor condition of the downstream face, it was noted that there were numerous significant horizontal and vertical cracks on the upstream face, many filled with calcite. Finally, it was found that the wave wall was also in poor condition and it was noted that it does not reach 'high' ground at the left hand end of the dam.

Photos show new membrane on upstream face of concrete dam (left) and auxiliary overflow (right) *Courtesy of Eric Wright Civil Engineering Ltd and MWH*

The solution

The downstream face of the main dam was cleaned and loose concrete, efflorescence and other surface deposits were removed. The concrete face was then protected from further deterioration by using a cementitious repair mortar and siloxane waterproofer.

The remedial works on the upstream face included the installation of a PVC geocomposite membrane, geonet drainage layer and associated drainage system to the upstream face of the main dam and the auxiliary overflow. The geomembrane is sealed on the concrete face along the foundation line and on the parapet wall 300 mm above the crest level to cover the joint between the upstream face and the parapet wall. The geomembrane covers a total surface area of 1,100m^2.

A Geomembrane drainage system was incorporated into the design to discharge water through 3 holes in the dam. Joints and cracks in the concrete were treated with an acrylic resin where the perimeter seal crosses the joint to prevent reservoir water bypassing the perimeter seal.

A reinforced concrete wave wall was constructed to the same dimensions and levels as the existing but it extended into the high ground at the left and right ends of the dam.

Finally, riprap erosion protection was laid at the left hand end of the dam to arrest erosion of the embankment. The material for the erosion protection was sourced from the reservoir basin.

Modifications to auxiliary overflow structure and wave wall extension *Courtesy of Eric Wright Civil Engineering Ltd and MWH*

Seathwaite IR after completion of refurbishment *Courtesy of Eric Wright Civil Engineering Ltd and MWH*

Early Contractor Involvement (ECI)

A key element to the success of the scheme was Early Contractor Involvement (ECI) which identified the following risks and mitigation:

- *Access and Site Restrictions:* Seathwaite is extremely remote and difficult to access without the correct transportation. Viewing the site at an early stage allowed the contractor to look at options for improving access, notifying suppliers to make the necessary provisions, and informing the Emergency Services, including Air Ambulance, of the prospective work and plan for evacuation of a potentially injured worker.

- *Site Cabins:* With the restrictions of space and access the contractor deployed two solar powered combination cabins. These cabins are an integral unit with toilet, welfare, drying room and canteen all in one small unit. This, along with ensuring biodegradable oil was used in any machinery, were all part of the planning process enabled by ECI.

- *Communications:* Seathwaite Tarn has no mobile phone signal or provision for a land line. This upfront knowledge led to the deployment of a satellite phone for emergency use.

- Scope of Work: As the contractor was involved 6 months prior to works commencing on site in attending progress meetings and visiting site with various parties, their knowledge of the contract scope was fully developed, more so than in a competitive format whereby a single visit and a viewing of the tender documents would be the norm. On this project, that detailed knowledge was fundamental to the success of the scheme.

- *Local Companies:* With a lengthy involvement prior to commencement on site, the contractor was able to contact local companies and residents to establish relationships well before the commencement of the works. This helped to get the best economical prices and facilitate an integrated working ethic with the whole site team who were interdependent of each others services, such as scaffolding and transportation. Local landowners and businesses were also contacted and were able to offer stores for materials and plant in a nearby barn, and house the specialist Waterproofing Contractors from Italy in the local B&B.

Mother Nature

Seathwaite is a beautiful location with extreme climatic conditions. Although the weather was generally good, over one weekend, the heavens opened and the full force of Mother Nature was unleashed. Water levels could not be contained, and the scaffolding was soon under 3 foot of water. Because of the provisions made for evacuation, and constant weather and water level monitoring, the contractor had removed all plant and materials and battened down anything that wasn't fixed. Despite this type of weather being typical to Seathwaite, the site agent reported that he had never seen thunder, lightening, wind and rain like it in his life.

The project was a great success, delivered to programme, budget, quality and without accident, and although the site ran smoothly, it was the measures implemented in the design /planning stage that ensured success.

Note: ***The Editor & Publishers thank MWH for providing the information contained in the above article.***■