Riding Wood IRE Spillway Improvements

considerate construction in the Peak District National Park

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Originally constructed in 1878, Riding Wood Reservoir is located in the picturesque Holme Valley in West Yorkshire, close to the Derbyshire border within the Peak District National Park. Having a storage volume of 235,000m^3, Riding Wood Reservoir is registered under the Reservoirs Act 1975, and is one of four reservoirs in the Holme valley that supply Holmbridge Water Treatment Works which, in turn, provides mains water to the major urban populations of Dewsbury, Batley and Heckmondwike. The spillway improvement work at Riding Wood formed part of Yorkshire Water's programme of Reservoir Safety Works affecting the series of reservoirs in the valley.

Completed spillway and outlet structure *Courtesy of Mott MacDonald Bentley Ltd*

Project need

After a statutory inspection in December'06, the need to investigate the performance of the existing spillway was identified to ensure continued compliance with the Reservoirs Act 1975. The inspection report also recommended investigation of the material in the embankment crest with respect to its ability to contain flood waters.

Project scope

The subsequent investigations of the existing spillway, including testing of a physical model produced by CRM Rainwater Drainage Consultancy, highlighted a clear requirement to improve capacity. This would ensure the Probable Maximum Flood (PMF) could be safely conveyed in accordance with the requirements stated in the ICE publication "Floods and Reservoir Safety". A number of options were considered to address this, resulting in the decision to provide a new, larger spillway on the left-hand (west) side of the reservoir, a different route to the existing spillway. The existing spillway was to be retained and modified to convey reservoir bywash flows only. The project also included construction of a new vehicular bridge to convey an existing public road over the new spillway and works to raise the existing clay core of the reservoir embankment.

As a framework partner to Yorkshire Water under their Clean Water West AMP4 framework, Mott MacDonald Bentley (MMB) was commissioned to undertake design and build responsibility for the £3.8 million scheme.

Consultation and planning

Previous works at Ramsden reservoir, located immediately downstream of Riding Wood, had already drawn the interest of the local community. Riding Wood reservoir is in a highly rural location with the public road crossing it primarily used by hikers, cyclists and other leisure users. During the initial design development, a public "open evening" was held at a local school to present improvement works proposals and obtain feedback. Individual discussions were also held with other stakeholders. This helped finalise the proposals for progressing to detailed design.

A planning application was submitted for the spillway improvement. As the works were located within the Peak District National Park, the Planning Authority was particularly interested in the final appearance to ensure it was suitable for the setting. Specific requirements were stipulated with respect to the finish details.

Riding Wood forms part of a cascade of three reservoirs. Therefore, the operational requirements of this entire system had to be considered as well as allowing provision for flood management during the construction works. MMB worked with Yorkshire Water and other stakeholders to devise a strategy for programming the works in the immediate area, whilst continuing to safeguard water supplies and maintain acceptable standards of safety. In addition, the reservoirs in the valley form an important leisure fishing resource, and the works were planned to minimise impact on this.

Existing spillway, retained for bywash
Courtesy of Mott MacDonald Bentley Ltd

Design

The general alignment of the new spillway is across relatively flat, open ground before descending to Ramsden Reservoir downstream. This route had the advantage of providing a relatively simple form for the structure and allowing suitable working areas for construction.

To help determine the hydraulic design requirements, a HEC-RAS computational model was constructed. This was supplemented with hand calculations for specific items, such as, the overflow weir and tumble bay. To minimise the required length, an ogee weir was selected. The hydraulic design was later verified with a physical model of the spillway.

It was agreed with YW that the spillway should be considered as two sections. The upper section was to be designed to convey the PMF flows away from the reservoir embankment. A freeboard allowance, in accordance with guidance in the US Bureau of Reclamation's "Design of Small Dams", was included. Once at an agreed distance from the embankment it was considered unlikely that any water escaping from the channel would pose a safety risk to the reservoir. As a result, the lower section of the spillway conveys the 1 in 500-year flood flows, including a suitable freeboard allowance. Flows in excess of 1 in 1,000-year peak flood flow will overtop the formal channel and pass along the trapezoidal cutting above.

Installation of flexi-arch bridge
Courtesy of Mott MacDonald Bentley Ltd

The new spillway is of a rectangular, open channel form, and reinforced concrete construction. The internal wall faces incorporate a "stone effect" finish whilst any visible external wall faces are clad in natural stone. Where possible, the spillway was designed to be constructed within the existing ground, and incorporate graded slopes above it to help minimise visual impact.

As the spillway crosses the line of an existing public road, a new traffic bridge was also included. A pre-cast concrete "flexi-arch" bridge system, as produced by Macrete Ireland Limited, provides the appearance of an arched bridge, similar to the bridge over the existing spillway. The design incorporated natural stone-clad spandrel walls and parapets as required by the Planning Authority. The bridge design eliminated the need for bridge bearings, thus, reducing inspection and maintenance requirements. The local Highway Authority was keen to see this bridge design implemented as a first for the county.

The existing crest level monitoring records were reviewed to assess the historical settlement of the embankment. A typical annual settlement rate was then determined and used to provide a value of anticipated future settlement over the next 40 years. Based on this, a 90 metre length of the clay core was to be raised to help "future-proof" the new spillway design.

Construction

Initial site preparation began in March 2009 with the main construction works commencing in June of that year, following approval by the Planning Authority. To ensure compliance under Section 10(6) of the Reservoirs Act 1975, the spillway improvement had to be completed to a functional standard by 29 December 2009.

To achieve this, the construction works were initially concentrated on the tumble bay, and the upper section of the spillway channel. During 2010, the remaining elements of the works were undertaken. Construction works were substantially complete in August 2010 with final landscaping and reinstatement works currently ongoing.

Construction of the new spillway was influenced by the existing topography and ground conditions, especially down the steep valley side leading to Ramsden Reservoir. The outlet structure became a stepped concrete design to help remove energy from the discharging flows, whilst providing a ground retaining function. The design also specified materials that could be easily transported where access was limited. An innovative, movable scaffold staircase provided safe access for workers to the spillway itself.

To meet one of the planning requirements, the walls of the spillway structure include a "stone effect" formliner finish. A mould was taken from the walls of the existing tumble bay structure by Max Frank Limited. This mould was then used to produce the formliner panels which were fixed to the formwork.

In addition, "stone effect" pillar details were formed in the concrete finish. The formliner panels and pillars were then stained using PICStain by PICS UK, a product combining metallic salts in a mildly acidic water-based solution, which when applied to concrete reacts with the free-lime in the cement to colour-etch the surface, creating a variegated finish.

To reduce the risk of damage to the spillway due to adverse weather conditions during construction, an SGB Coverspan movable canopy was erected over the working area where possible. This also had the advantage of improving staff welfare and, thus, productivity. The additional cost of providing the canopy was more than offset by the reduction in delays and re-work.

The overflow weir is of an ogee type to match the appearance of the existing structure. It is a unique pre-cast concrete design, comprising 29 units of three types with differing lengths, to help

Completed spillway viewed downstream from the public road
Courtesy of Mott MacDonald Bentley Ltd

Completed bridge and tumble bay showing stone-effect finish
Courtesy of Mott MacDonald Bentley Ltd

provide construction savings and consistency in appearance. The design of the weir units enabled the production of a single mould which could be simply modified to produce the three unit types, supplied by Whites Concrete of Dewsbury.

A test unit was produced and inspected by the project team. This helped refine the manufacture and confirm and enhance the delivery and installation requirements. The weir took 1 week to construct, whereas a conventional design would have required around 4 weeks and additional skilled labour.

The pre-cast concrete arch bridge structure was produced and tested off-site and then delivered for installation. Once the bridge footings were in place, the arch and spandrel wall units were installed by crane within a day. The void over the arch was then backfilled with mass concrete and final surfacing and finishes provided. This form of construction was considered to be simpler and safer than for a conventional beam bridge, reducing construction time by approximately 20%.

Conclusion

The Riding Wood spillway improvement works were undertaken within a short timescale, to achieve key milestone dates, and are now substantially complete. Despite the tight constraints, namely site topography, adherence to strict Planning Authority requirements and meeting public expectations, the outcome was certainly a success. Best practice in safety was rewarded with a project accident frequency rate (AFR) of zero and recognised when Riding Wood won the CECA (Yorkshire & Humber) Linda Grant Health & Safety Award 2010.

Outcomes and learnings

Yorkshire Water was pleased with the reaction to the completed works, with much praise received from the Planning Authority, the general public and industry peer awards. The new spillway has even made an appearance on the BBC's "Countryfile" programme. The learning gained and techniques developed during the Riding Wood project have been carried through to subsequent reservoir improvement projects.

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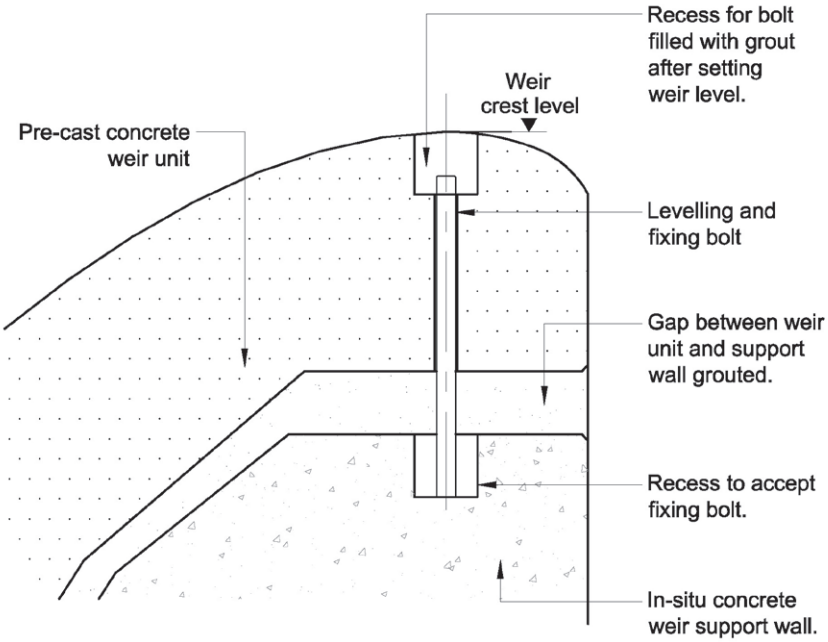

Ogee weir installation detail and, right, sample weir unit

Courtesy of Mott MacDonald Bentley Ltd