Winscar Reservoir – a case study
membrane repairs to a leaking reservoir
by J R Claydon, BSc(Eng), ACGI, DMS, FICE, All Reservoirs Panel Engineer

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inscar Reservoir, located just south of Holmfirth, W.Yorkshire, was constructed between 1972 and 1975 for water supply. It has a capacity of 8 million cubic metres and the yield is 22 Ml/d. The reservoir is formed by a rockfill dam with a maximum height of 53m and a crest length of 520m. The embankment is made of compacted sandstone with an upstream slope of 1V on 1.7H and 1V on 1.4H downstream. A two-layer membrane of dense asphaltic concrete covers the 25,000m² upstream face of the dam. A cement grout curtain extends beneath the upstream toe to depths of up to 70m.

The Problem
In January 2001 a large spring issued from the toe of the dam with a flow of about 15 litres/second. The reservoir was drawn down as a precaution and the response of seepage flows was closely monitored. Flow reduced at approximately half-depth of the reservoir, suggesting a major defect at this level.

The upstream face of the dam was inspected using roped access and about sixty defects were observed in the upper half of the asphaltic membrane. Most were blisters and small cracks but there were also more persistent cracks that coincided with construction joints between panels. This type of defect had not been previously encountered at Winscar and initially seemed to be the most likely explanation for the new leak. However, core drilling at crack locations was unable to confirm full-depth cracking.

The lack of conclusive evidence as to the location of the leakage meant that the reservoir had to be drawn down completely. A range of measures were needed to avoid environmental damage, which included blending of different quality waters; filtration through straw bales, geotextiles and hessian, settling basins; and timing of discharges. Emptying of the reservoir took over six months and the care continued during the repair works with the old submerged Dunford reservoir brought back into use to settle water before discharge to the river.

The solution
The uncertain condition of the asphaltic membrane prompted the decision to reject patch repairs in favour of major refurbishment of the entire water proofing element with all works completed before the winter rains of 2001/2002.

The technical feasibility of various engineering solutions was investigated by YWS and its consultant, Montgomery Watson Harza and Arup. The logistics, environmental and planning aspects were considered and the costs estimated. Two options gained high evaluations:
The construction schedule was very challenging, because of the
less influenced by these factors than the asphaltic concrete and on
works, which might have extended into a second year if inclement
necessary spe cialist plant was a problem, as was the timing of the
geomembrane solutions.

YWS select list for both the asphaltic concrete and the
Compliant tenders were received from main contractors on the
weather conditions prevented completion. The geomembrane was
and a contract was awarded to
It was decided that the geomembrane solution should be adopted
this occasion there was also a clear cost advantage.

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and a contract was awarded to Morrison Construction Ltd, with
Carpi Tech as specialist sub-contractors.

Grouting operations during 2001
A possible explanation for the increase in seepage beneath the dam
over the life of the reservoir was that the grout curtain had been
subject to leaching. Attention was directed at the foundation to the
left of the culvert, since the new leakage was concentrated in that
compartment of the foundation. Two phases of grouting were
undertaken with an interim review to allow methods to be
evaluated and modified. Over 20T of microfine cement were injected
and the average consumption was 35kg/m. The grouting work was
carried by Skanska-Cementation as a sub-contractor to Morrison.

Geomembrane
The compliant tender submitted by Morrison/Carpi was based on
an HDPE membrane approved by the Drinking Water
Inspectorate under Section 25 (1) (a) of the Drinking Water
Regulations, 1989. An alternative PVC based geomembrane
proposed by Carpi Tech had been used on over 60 dam projects
worldwide but had never been used previously in a water supply
reservoir in the UK and had not been submitted for approval.
Product details and performance were presented to the DWI who
stated that this was an issue that should be dealt with by YWS
under the provisions of Regulation 25 (1) (b) ie the company
might well consider that approval is unnecessary because of the
small risk posed by use of the unapproved material. The PVC
based material was adopted - modified for use in the Peak District
by colouring it dark green.

Geocomposite liner
Sibelon CNT 3750, a Flag S.p.a Italian product was specially
manufactured in Italy for Winscar over a period of a week in July
2001. The geocomposite liner was supplied by the factory to
length in standard 2.10m wide rolls. Three rolls were then welded
by automatic twin track machines in a prefabrication yard to
construct wider panels in order to maximise quality and minimise
installation time on site.

The geocomposite liner is mechanically fixed to the dam using
watertight anchorages around the periphery and by tensioning
devices on the face. Tensioning prevents wrinkle formation that
may ultimately lead to cracking. The tensioning assembly, which
is patented by Carpi comprises coupled stainless steel profiles.
The lower profile is fastened to the upstream face by anchor rods
embedded in epoxy resin. The embament depth was determined
on the basis of a fifty year return gust wind speed. The liner covers
the lower profile and is clamped and fastened by the upper profile.
A PVC cover strip overlies the coupled profile and is welded to
the underlying liner. The liner was installed between August and
December 2001.It could have been installed more quickly but the
programme was interrupted by work on the grout curtain.

Leak detection system
The underside of the geomembrane is drained into the culvert
down the dam. Any leakage is measured over ‘V’ notches weirs
and transmitted through the telemetry system A leak detection
system has been installed to pinpoint the source of any future
leakage through the new liner. A network of fibre-optic cables was
fastened to the asphaltic concrete surface and installed under the
liner in a series of loops. The system uses a laser source to
measure the wavelength of light reflected back down the cable
and sense temperature. The temperature at any point along the
cable route varies depending on the season, reservoir temperature
profile and other factors. However, passing a current through the
external sheath of the fibre optic cable can induce an artificial
increase in temperature. In dry conditions the temperature rise
would be constant but energy is lost in the presence of water and
anomalies can be detected.

Performance
The performance criteria for the design of the geocomposite liner
was that it should be capable of reducing leakage through the face
of the dam below 1 litre/sec against full reservoir head. Flow from
the primary compartment which covered the original asphaltic
cement facing is very small, It has shown a faint increase with
reservoir level and seepage was less than 0.02 litres/sec at three
quarters full reservoir head.

The current indications are that total seepage flow has reduced
considerably. It is estimated that the daily leakage during January
2001 of over 4,000m3 will be reduced to 500m3.

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major asset successfully.

Note: The author of this paper, J R Claydon is Solutions Manager
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