OVERCOMING AGGRESSIVE WATER CONTAINMENT REQUIREMENTS

Geomembrane Floating Covers have been used for over 40 years for a number of different functions including to protect and store precious water resources by both government and private bodies around the world. Floating covers offer a much lower cost solution than solid structures. In the recent years there have been a steady increase in the demand for such engineered water containment systems using geosynthetic materials to reduce water losses from evaporation and seepage, simplify water quality management and to provide a sustainable system for their communities.

Compared with other potable water reservoirs the composition of water produced in this case study by the site RO plant features elevated water temperatures and an extremely negative Langelier Saturation Index (LSI). LSI is a measure of the waters ability to absorb or deposited calcium carbonate (water hardness). The stored water was also chlorinated which combined with the low LSI characteristics created a highly corrosive liquid and challenges for the geosynthetic barrier membrane.

As designer it was to consider the geomembrane material properties necessary for the liner and the floating cover and the aggressive water chemistry in this application. One of the main challenges was to propose the right material for our client to meet their long service life requirements. Floating cover systems require materials that have high tensile strength and puncture resistance, are flexible and resistant to flex cracking, dimensionally stable. This application also required the materials to contend with high UV loading and ambient temperatures, high water ambient temperature and the aggressive low LSI chlorinated water.

Project Background

- Remote mine site:
  - High UV
  - High ambient temperature and temperature range
  - Low rainfall
- Shallow sub-grade over clastic limestone
- Sequential up-grade of 3 storages to current state of industry practice.

This storage was originally constructed using CSPE material which provided a service life of 16 years. It was refurbished using an LLDPE based cover material which experienced blistering and cracking in less than 2 years. The storage was rebuilt using a highly fortified multi-layer Polyethylene cover material and a highly fortified HDPE liner. These materials also experienced material cracking in less than 2 years.
Material Selection

Investigations revealed that the low LSI water was degrading Polyethylene materials. The LSI was found to be as low as \(-3\) and combined with chlorine at elevated temperatures was very aggressive.

CSPE was selected as the most suitable material technically for this application. This material has been used in floating cover applications for over 35 years. In applications such as this it is used in a scrim reinforced format and provides excellent mechanical properties for floating cover applications combining tensile strength, flexibility and excellent UV resistance. CSPE also showed resistance to chemical degradation in this application with a known service life with low LSI water. There was insufficient time available to test other materials for durability performance in the project specific liquids.

CSPE is a highly specialist product with regard to resin manufacture, sheet material formulation, sheet manufacturing processes and installation techniques. All of these elements influence the quality outcomes of the completed installation. Burke Industries in San Jose California were selected as the material partner for this project. Having closely worked with Burke industries over many years successfully delivering CSPE covers across Australia; Fabtech are an accredited installer / designer for their products in Australia.

The following challenges and skills needed to be demonstrated to minimize risks in project delivery:

CSPE require specialist considerations;

- Narrow roll format makes it preferable to pre-fabricate materials post manufacture to large panels for site construction
- CSPE is a synthetic rubber which cures in oxygen. This process enhances the materials durability characteristics but also makes primary welding more difficult. Fabtech accordingly manage material production and logistical processes to minimize the time for material production to site installation give the material shipping requirements from the supplier’s facilities in San Jose.
- Following material pre-fabrication in Fabtech’s factory facilities material supply to site is carefully timed to minimize the elevated temperature history of the material prior to welding to maximize weld quality.

- Consistent with many critical asset projects an extensive material Quality Assurance program was implemented. This included oversiteing material production at the manufacturer’s facility and independent laboratory material compliance testing to complement the manufacturers Manufacturing Quality Control processes.

Lining System Design

The storage barrier system was required to have very low seepage rates to protect the underlying foundation materials. To achieve this Fabtech designed a double liner system.

This system implemented used a reinforced CSPE primary liner over a Geocomposite drainage layer over a compacted soil liner.

An common earthen anchor trench secured the lining system and cover materials. Care was taken while constructing the anchor trench in order to achieve a straight edge for the geomembrane material to transition into the anchor trench and avoid stress concentrations for the geosynthetic materials.

Prior to the installation of the lining system a thorough inspection of the subgrade was carried out. Subgrade soft spots were excavated and repaired.

Design Detail

The specification required the primary CSPE liner to be factory pre-fabricated into large quality assured panels maximizing factory welding and minimizing site welds. The installed membrane was inspected by normal construction quality assurance procedures and also a liner electrical integrity survey to validate a very low defect rate in the as constructed geomembrane. The site was known to provide poor conditions for electrical liner integrity surveying resulting in low sensitivity. To ensure that an accurate integrity survey could be performed the geomembrane was underlain with a conductive geotextile which also reduced stresses imposed on the geomembrane from the drainage layer.

Beneath the conductive cushion geotextile was a geocomposite drainage layer. A geocomposite was selected with sufficient flow capacity to ensure that the secondary compacted soil liner would experience negligible hydraulic head even when leaks were present in the primary geomembrane liner. The filter fabric bonded to the bi-planer drainage net served to prevent soil infiltration into the drainage and erosion of the CSL should leaks occur.

Any seepage through the primary geomembrane would be collected in a sump and extracted by a riser pipe and automatic pump.
Construction Quality

To achieve low seepage through the primary GMB liner

- Experienced contractor; IAGI Approved Installation Contractor (AIC), IAGI Certified Welding Technicians (CWT), and experienced in the specific project materials
- Panel design to minimise welding
- Factory pre-fabrication of material to minimise site welds
- Pre-testing of welded seams prior to construction seams
- Construction quality assurance testing of welded seams

Floating Cover

The floating cover was required to keep the stored potable water clean, chemically stable and eliminate evaporation in this harsh remote environment. The cover is required to function and cycle between the storage from empty to full. This achieved by a series of floats and weights which tension the cover material and adjust for the changing geometry as the cover cycles full to empty.

The tensioning weights (sand tubes) also provide drainage channels for draining and collecting rain water from on top of the cover. The tensioning ballast was configured in a central plate configuration. In addition to tensioning mass and floats the cover incorporated a hatch to allow dive inspections and walkways to allow safe trafficking across the cover to the hatch, water sampling ports and the rain water pumps.

Rain water disposal is facilitated by the channels formed by the sand ballast tubes and foam floats of the tensioning system. These channels drain surface water to one of two aluminum sump wells installed in platforms. The stainless steel bodied submersible pumps within the sump well pumps any accumulated water to the perimeter of the storage. Fabtech incorporated two on cover storm water management pumps to provide redundancy. The pumps are controlled automatically by an integral float switch.

Air venting was incorporated to ensure the cover would float correctly, drain surface rainwater evenly and avoid areas of dirt and debris accumulation.

As with the liner reinforced CSPE material was specified for the cover. This material combines good UV and flexing durability with resistance to chemical attack from the low LSI chlorinated potable water with suitable mechanical strength required for the additional tensile loads experienced by a floating cover.

The cover was installed when the storage was empty. This is the preferred construction method as it allows designed cover tensions and geometry to be achieved more reliably. As with the liner the cover material production rolls were factory fabricated to specific geometric panels to be installed at specific locations minimizing the amount of factory performed welds, minimizing material wastage, minimizing the required site construction duration. Also this allows the location of welds to be separated from stress concentration points assisting in creating a durable design.

Hydrostatic and Flotation testing / commissioning

Following installation of the cover over the liner the storage was hydrostatically commissioned before being accepted into service. This involved filling the storage in stages progressively increasing the hydrostatic load up to the full design loads while monitoring any seepage present in the leak detection and recovery system. The implemented design together with a precision construction process achieved zero seepage during the commissioning process.