El Vado Dam Case Study
Geomembrane

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• El Vado Dam is located on the Chama River in north central New Mexico

• Construction was completed in 1935 by the Middle Rio Grande Conservancy District

• The facility was transferred to the BOR in the 1950s

• Spillway is a steel lined structure and subject of separate Dam Safety project.
Embankment:

- Characterized as a steel-faced rockfill dam (one of a few in the US)
- About 175 feet tall, and 1,300 feet long
- Total storage capacity about 185,000 acre-feet
- Sole water barrier is the steel plate on the upstream face.
- Upstream cutoff wall (grout curtain and concrete filled trench)
Embankment Construction
Embankment Construction
Coatings Replacement (~1950s)
Left Abutment Landslide

“lobe”

Foundation Seepage Issues
Embankment Deformations and Faceplate Distress
Embankment Deformations and Faceplate Distress
Expansion Joint Cracks

crack at trough of expansion joint

(a) 

(b)
Void that must be filled prior to geomembrane installation
Seepage Reduction Options

- Option 1 – Geomembrane over Existing Steel Liner
- Option 2 – Replacement of the Damaged Steel Expansion Joints and Faceplate Panels *(Enhanced O&M and EWS)*
- Option 3 – New Exposed Geomembrane Liner
- Option 4 – New Geomembrane with Articulated Concrete Block Overlay
- Option 5 – New Hydraulic Asphalt Liner
- Option 6 – New Reinforced Concrete Liner
- Option 7 – New Roller Compacted Concrete Liner
- Option 8 – Left Abutment Seepage Blanket
- Option 9 – Foundation Grouting
- Option 10 – Embankment Cutoff Wall
- Option 11 – Drained Reservoir with no Structural Modifications
- Option 12 – Restriction below Elevation 6844 with Spillway Modifications
- Option 13 – Dam Removal
Backfill Grouting

Phase 1

Phase 2

NOTES

1. Backfill grouting to be completed through drilled holes through the steel faceplate spaced no greater than 25.0 horizontally and 4.0 parallel to stage. At least two injection ports to be conducted for each steel faceplate except when less than 10.0 width at lowest. Notice holes as needed where backfills may be present. Drilled holes shall be drilled before grouting may commence. The Contractor shall be the sole force to determine the rubber grout to be used to seal the holes.

2. See specifications for backfill grouting sequence.

3. Grout shall be used to seal good holes when not in use.

4. See specifications for fitting, valve, flow meter, and gauge requirements.

5. Flow into each grout location shall be measured at the backfill assembly.
Layered System

- PVC Liner
- Cushion
- Geonet
- Steel Plate
- 4 – 8” grout
Selection of Exposed Geomembrane Lining System

- Market Research to find viable materials to test
- Materials testing of viable products
- Product/Company Selection (Sole Source)
- Design Consultations (Design Build)
- Field Trials
- Build/Construction
Geomembrane Research

Objective: Find suitable geomembrane product for an exposed installation with long-service life and mounting system for securing to the steel faceplate.

- High-density Polyethylene (HDPE) (Design life > 50 yrs)
- Linear Low-density Polyethylene (LLDPE) (Design life 20 to 40 yrs)
- Polyvinyl Chloride (PVC) (Design life > 75 to 100 yrs)
- Ethylene Propylene Diene Monomer (EPDM) (Design life ~ 50 yrs)
- Flexible Polypropylene (fPP) (limited info)

- LLDPE and fPP removed early on due to shorter design life and limited exposed installation examples
Market Research

• Design Standard No. 13, Chapter 20- Geomembranes:
  
  • “Specifically formulated PVC geomembranes (using the highest quality UV stabilizers) are used in exposed dam facings when incorporating additives commensurate with European standards. “

  • HDPE geomembranes perform well when left uncovered; however, they can be susceptible to stress cracking if the resin is not appropriate. Wrinkles are common due to their high coefficient of expansion.

  • EPDM geomembranes have excellent resistance to weather and UV exposure and resist abrasion and tearing. EPDM can tolerate temperature extremes and maintain flexibility at low temperatures.

• Market research also involved paper research, consulted TSC lab (Jay Swihart), Geosynthetic Institute (Koerner’s), site visit (Upper Blue Dam), vendor and installer calls, etc.
Reflects latest practices in Europe where most exposed geomembrane installations have been completed.
Geomembrane Research

- Engineering properties of the viable geomembrane materials are well understood and not evaluated as part of the market research.
  - Elongation
  - Rupture strength
  - Tensile strength
  - Brittleness
  - Ultra-violet (UV) resistance

- Five viable material vendors were identified
  - (PVC 1 and PVC 2),
  - (EPDM 1 and EPDM 2),
  - HDPE.

**FOCUS of research: Damage/ Impact Resistance**
Sources of Geomembrane Damage

• A log boom will be installed to prevent damage from floating debris and boat impacts.
• Resistance to ice loads has been researched by others with favorable results.
• Damage most likely from vandalism.
Laboratory Impact Testing of Geomembranes

• Impact tests were used to subject the specimens to 10- and 15-pound drop weights at four different temperatures (70, 32, 0, and -40 °F).

• The study attempts to characterize the relative impact resistance of the geomembrane materials being considered to aid in selection of a preferred geomembrane material for the exposed lining alternative.
Vertical Drop

Falling Hammer
ASTM D5635
Damage Classification

Category 1:
- Impact slightly visible on surface
- No evidence of impact on the back
- No leakage from vacuum pressure test

Category 2:
- Impact moderately visible on surface
- Impact slightly visible on the back
- No leakage from vacuum pressure test

Category 3:
- Impact well defined on surface
- Impact moderately visible on the back
- No leakage from vacuum pressure test

Category 4:
- Tearing around the perimeter of the impact
- Impact clearly visible on the back
- Thinning & cracks radiating < 1-inch from impact
- Apparent leakage from vacuum / pressure test

Category 5:
- Complete impact device pass through
- Definite thinning of the membrane section
- Cracks radiating > 1-inch from the impact
- Clear leakage from vacuum / pressure test
Plasticizers can be added to improve PVC ultra low temperature performance but can impact UV resistance.
Field Trials
Field Trial Demonstration Solicitation

Goals:

• Have multiple geomembrane vendors/installers participate to further inform market research.
• Determine best method for securing geomembrane to steel faceplate and other concrete features.
• Inform the final design drawings and specifications.
• Up to ~ 5 contracts would be awarded. Each test panel about 30’ x 30’ in size, include all the features for the full-scale installation.

• Advertised on FedBizOpps and GSA Schedules.
• One qualified Contractor Bid: Carpi USA
Required “Geo” Materials

• Geonet Drainage Layer (along base of installation for liner leakage)

• 500 g/m² non-woven geotextile cushion (later increased to 2000 g/m²)

• 120 mil PVC geocomposite membrane (500 g/m² geotextile cushion backing)
Geomembrane Field Trial

upper perimeter seal

intermediate tension profiles
Geomembrane Field Trial
Geonet Drainage Layer
Tensioning Profiles
Geomembrane Field Trial
Completed Test Section
Geomembrane Field Trial
(500 g/m² cushion not adequate)
Geomembrane Field Trial Key Findings

- PVC geomembrane materials are very flexible and well suited to cover the irregular surface at El Vado Dam.

- Surface preparation; removal of rust/scale and hazardous coatings needs to be planned for.

- Careful consideration for welding of dissimilar materials (stainless mechanical connections to mild steel faceplate). Long term cathodic protection will be required.

- A heavier geotextile cushion (approximately 2000 gram/square meter) should be used to cover the existing steel faceplate irregularities and bolts.
Industry Day and Sole Source Justification

• Advertised on FedBizOpps and GSA Schedules.
  • One geomembrane installer attended: Carpi USA

• Received participation from grouting, earthwork, welding, traffic control and other contractors that may also serve as subs.

• Acquisitions leveraged market research, field trial interest, and industry day participation to justify sole source and Buy America deviation.
  • Sole source was obtained for the Sibelon CNT 4400 geomembrane composite liner. The geonet and geotextile cushion could be obtained from US vendors, but did not exclude overseas vendors.
Contracting with Carpi USA

• Sole Source documentation was complete and a solicitation was developed which included:

  • Design Consultation Meetings
  • Laboratory Testing by Carpi and Follow up Field Trial (reflecting design meetings and lab testing)
  • Seepage Modification Construction
Design Consultation Meetings

- Held over ~ 6 months (~during 30 to 60% design)
  - Required steel faceplate preparation
  - Perimeter watertight seal details
  - Intermediate tensioning profile connections
  - Liner drainage system
  - Review of “Geo” specifications and drawings
  - Leak detection instrumentation
  - Facilitated meetings with prospective grouting contractors
  - Prepared preliminary construction schedule and cost estimate
Carpi Laboratory Testing
Figure  Surface Preparation Methods Evaluated: A) Hand held wire brush, B) Sanding disc, C) Wire wheel soft, D) Wire wheel coarse, E) Grinding disc, F) Sand blasting.)
Coatings Removal and Hazardous Materials Analysis
Mechanical Connection Trials
Expansion Joint Crossing and Covers
Current Status and Construction Schedule

• Currently under contract with Carpi USA.
  
  • Mobilization ~ March 2022
  • Backfill grouting ~ May – July 2022
  • Foundation grouting ~ July 2022 – March 2023
  • Geomembrane Installation ~ May – Sept 2023
Project Team

- Geotechnical: Kevin Schaeffer, Jason Shamrock
- Geology: Cassie Wagner
- Grouting: Chris Slaven, Westin Joy
- Concrete: Miguel Hernandez
- Mechanical: Olaff Huerta, Miki Salamon
- “Geo” Materials: Jay Swihart, Mike Walsh, Brian Baumgarten
- Electrical: John Kelly
- Coatings Removal: Kevin Kelly
- Cathodic Protection: Daryl Little
- Construction Liaison: Shawndra Benoit
Materials & Corrosion Lab Capabilities- Geosynthetics

• Technical expertise related to the use of geosynthetics and polymeric materials:
  • Geosynthetics (geomembranes, geotextiles, geonet, geocell, geogrid, geocomposite, geosynthetic clay liner, geofoam)
  • Waterstops (PVC & Hydrophilic)
  • HDPE Pipes
  • Sealants
  • Expansion Joint Fillers (sponge rubber)

• Services:
  • Inspections, design, drawings, and specifications

• Conduct applied research to evaluate materials
Questions?